

## ABSTRACT

Title of dissertation: CAREER ASPIRATIONS OF HIGH SCHOOL  
MALES AND FEMALES IN A SCIENCE,  
TECHNOLOGY, ENGINEERING, AND  
MATHEMATICS PROGRAM

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With the large number of Science, Technology, Engineering, and Mathematics (STEM) jobs across the nation and state which are unfilled due to lack of interested and qualified STEM applicants, there is a need for more students to leave high school, enter college in STEM majors and continue through the STEM pipeline to STEM careers. The purpose of this study was to determine the degree to which high school students who participate in a STEM program from elementary through high school aspire to STEM careers compared to students with similar mathematics achievement who did not participate in the STEM program. Of particular interest was the effect of the STEM program on female aspirations toward STEM careers. Career aspirations was self-reported one month before students graduated from high school on a school and graduates of the STEM program were compared to graduates with the same gender and a similar mathematics test score. The quantitative, retrospective

study found that 58.75% of the students in the STEM program aspired to STEM careers after high school compared to only 40.00% of students with similar academic achievement that were not in the STEM program. Students in the STEM program were 0.47 times more likely to aspire to STEM careers compared to their peers who did not participate in the STEM program. The study also found that males in the STEM program were 0.35 times more likely and females in the STEM program were 1.0 times more likely to aspire to STEM careers than same gender students not in the STEM program. The effect on gender was not statistically significant due to the small number of females in the study; however, the data is important because females in the STEM program were twice as likely to aspire to STEM careers, in particular engineering. The STEM program effectively achieved one of its goals to increase student interest, especially females, in aspiring to STEM careers.

CAREER ASPIRATIONS OF HIGH SCHOOL MALES AND FEMALES  
IN A SCIENCE, TECHNOLOGY, ENGINEERING,  
AND MATHEMATICS PROGRAM

By

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## Dedication

I dedicate this dissertation to my loving and caring parents, Thomas and Linda Lehman. They always support me no matter what I want to do, and most importantly they have instilled in me the confidence that I can do whatever I want to do. Thank you for helping me to earn all of my college degrees that have opened up so many opportunities in a rewarding career. I love you both very much!

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# Chapter 1: Introduction

## Introduction

In an era of reform, Science, Technology, Engineering, and Mathematics (STEM) education is a hot topic about preparing students for the jobs needed in the twenty-first century. National attention has been given toward building a pipeline from kindergarten through college, educating students to improve academic skills and motivating students to pursue STEM careers. United States President Barack Obama has put the STEM crisis front and center in his education, job, and financial initiatives. “Think about the America within our reach: A country that leads the world in educating its people. An America that attracts a new generation of high-tech and high-paying jobs,” said President Obama in his January 2012 State of the Union address (Koebler, 2012, p.1).

At the earliest stages of the STEM pipeline, schools are increasing the rigor of science and mathematics courses and raising expectations for students to master essential skills to better prepare them for STEM careers. At the end of the pipeline, STEM jobs are unfilled because the number of jobs is increasing, but not enough students are graduating from college in STEM fields to meet the job demand. A report by the President’s Council of Advisors in Science and Technology (PCAST) concludes that one million additional STEM graduates are needed over the next decade to fill the growing number of jobs that require STEM skills (PCAST, 2012). The 2015 federal budget invests \$2.9 billion in programs across the federal government on STEM education which is a 3.7% increase over 2014 enacted funding

levels (White House Office of Science and Technology Policy, 2014). The demand to fill STEM-related jobs has not yet been met, despite increased efforts by educators to improve students' science and mathematics skills and increased financial support by the federal government to improve STEM education; because more students are needed to graduate high school motivated to pursue STEM-related fields in college.

A specific need is to increase the number of women interested in pursuing STEM careers. The participation and persistence of women in STEM-related fields is a national concern. "In particular, women are less likely than men to pursue degrees in STEM. If these disparities were corrected, the United States would be better able to fulfill the demand for STEM workers" (U.S. Congress, 2012, p. 5). Females are under-represented in STEM careers and there is a need for more women to enter the STEM workforce. Only 25% of computing/math positions and 11% of engineering positions were held by women, yet women make up 47% of the workforce (National Science Foundation, 2011). It is important to evaluate whether STEM education is preparing and motivating more young women to pursue STEM careers. Women's increased participation in the STEM workforce is essential to alleviating the shortage of STEM workers (U.S. Congress, 2012).

### Statement of the Purpose

One of the most important links in the STEM pipeline is the transition of students from accelerated science, mathematics, and technology high school courses to entering STEM-related fields in post-secondary education. Research is needed on whether current STEM programs at the elementary, middle, and high school levels are motivating more high school graduates towards careers in STEM fields. School

leaders need to determine whether the amount of time, money, and resources invested in a district elementary through high school STEM program has increased student interest in pursuing post-secondary education in STEM careers. The findings of this study can then provide educators with information on whether to continue or change STEM programming.

The focus of this study is to examine the career aspirations of high school graduates from a school district's STEM program compared to high school graduates with similar academic achievement not in the STEM program. The purpose of this study is to first determine whether more students who complete the school district's STEM program are interested in pursuing STEM careers after high school. Another purpose of the study is to examine the career aspirations of females in the STEM program to determine if more females are interested in STEM careers after high school who participated in the STEM program compared to females with similar academic achievement who did not participate in the STEM program.

The STEM program evaluated in this study begins with students in the elementary school and continues through high school. Students attend this specific school for the STEM program, but reside anywhere within the district. Elementary students with high scores on mathematics achievement tests are invited to apply to the STEM program. Students are then accepted to the STEM program based upon a selection process including interviews, aptitude tests, and problem solving skills. Throughout the program, students form a cohort of approximately 30 students with similar STEM teachers, STEM courses, and STEM activities each year. The STEM program is part of a comprehensive school with approximately 200 other students in

each grade level who do not participate in the STEM program. Since the purpose of the school district's STEM program is to increase student interest in STEM and to increase the number of students pursuing STEM careers after high school, the results of this research will help the local district's school officials determine whether the STEM program is fulfilling the goal of promoting interest in post-secondary STEM careers.

### Research Questions

There are two primary research questions for this study related to student interest in STEM careers after completing a STEM program from elementary through high school. The study will focus on comparing career interests of students in the STEM program to students who are not in the STEM program, but had similar academic achievement. The under-represented subgroup in STEM careers of females will also be analyzed to determine if there is a difference in the career interests of females in the STEM program compared to male students in the STEM program.

The first research question examines the career interests of students and whether a STEM program influenced students' career aspirations.

- Does being in a STEM program make a difference whether students with similar academic achievement aspire to STEM careers? If so, to what extent?

The question is designed to determine whether students in the STEM program are more likely, and by how much, to be interested in pursuing STEM careers after high school graduation.

The second research question studies whether the STEM program had a different influence on career aspirations of male students compared to female students.

- Does being in a STEM program make a difference whether male students with similar academic achievement aspire to STEM careers? Does being in a STEM program make a difference whether female students aspire to STEM careers? If so, to what extent for each gender?

The question is intended to determine among male students whether males in the STEM program are more likely to aspire to STEM careers, and to determine among female students whether females in the STEM program are more likely to aspire to STEM careers. The extent would be determined of how much either gender in the STEM program is more likely to aspire to STEM careers.

Both research questions will help evaluate the success of the STEM program in achieving one of its goals of increasing the number of students interested in aspiring to STEM careers after high school.

### Methodology

This research project is a non-experimental, quantitative study comparing interest in STEM careers and non-STEM careers of STEM program students versus students not in the STEM program but with the same gender and similar high ability in mathematics. The research includes an analysis of quantitative data available for high school graduates over the last four years who attended a public school district with a STEM program in elementary, middle and high school. Quantitative data analysis answered the research questions to determine whether or not students in the STEM program, particularly females, were more likely to graduate high school interested in pursuing a STEM career versus comparable peers not in the STEM program.

To compare similar academic ability of STEM program and non-STEM program students, the researcher used the Maryland State Assessment (MSA) mathematics scale score for the students when they were in fifth grade. This academic achievement measure is used as one of the criteria to determine STEM program acceptance when students transition from elementary school to middle school. Students in the STEM program primarily scored in the advanced level on a scale of basic, proficient, and advanced scores. There were two rationales for utilizing this high-stakes test math score as the data to determine the comparison group. First, research already supports that students with higher mathematics ability have a greater likelihood of aspiring to STEM careers (LeBeau, Harwell, Monson, Dupuis, Medhanie & Post, 2012 and Nicholls, Wolfe, Besterfield-Sacre & Shuman, 2010). Second, a goal of the STEM program is to increase students' mathematics skills from elementary to high school. In order for math ability to not be a confounding variable in the study, students in the STEM program are compared to students with similar mathematics achievement in elementary school.

The data used to determine STEM or non-STEM career interest was gathered by school guidance counselors every year a few weeks before high school graduation. Students complete a Graduation Exit Survey with a variety of questions about their post-secondary plans. One of the questions on the survey is "What will be your major focus of study?" Responses were then determined by the researcher as either STEM or non-STEM careers for the purposes of the research study. High school guidance counselors were also able to provide the list of STEM students graduating each of the last four years at the high school with the STEM program. The school district's data



management system provided the MSA mathematics scores of the STEM students and generated a list of comparison students with similar mathematics scores.

The study population included four years of data with approximately 30 students graduating from the STEM program each year. Data for students in the STEM program was paired with data of other students in the same graduating class with the same gender and similar MSA mathematics score. This allowed the researcher to hold academic ability as a constant variable when comparing career interests. The total sample of the study was 160 students.

### *Importance of the Study*

The findings of the study add to the current body of knowledge regarding STEM education, and support the national pursuit to prepare more students for the job-demands of the future in STEM-related fields. The study determines whether the STEM program increases the likelihood that students who participate will be interested in STEM as their major focus of post-secondary study. If the research revealed that more STEM students are interested in pursuing STEM-related college majors then the STEM program is fulfilling one of its primary goals. The purposes of the STEM program are to prepare students with knowledge and skills necessary to succeed in college and careers; and to promote interest in STEM-related fields of study after high school so that students continue through the STEM pipeline to STEM careers. A 2010 report to the President concluded, “To improve STEM education, we must focus on both preparation and inspiration. And we must inspire all students to learn STEM and, in the process, motivate many of them to pursue STEM careers” (PCAST, 2010, p. 6).

The findings also provide insight on whether STEM programs increase the interest in STEM careers of one of the most under-represented populations in STEM occupations, women. This study is important to determine whether STEM programs increase the likelihood that female students will graduate from high school interested in continuing their education at the post-secondary level in STEM-related fields. Educators at all levels will be provided with valuable information on whether or not STEM programs encourage the STEM interest of female students.

The findings and recommendations of the study are also important for the school district with the STEM program to determine whether the goal and purpose of increasing STEM interest has been met. The district has invested time, resources, and money for the last decade to build, grow, and maintain the STEM program. With a small cohort size of less than 30 students every year, the STEM program needs to yield results in order to continue. As a comparison, national data reported in 2013 by the Alliance for Science & Technology Research in America (ASTRA) reported only 28.5% of high school students are interested in STEM. By subject, 9.4% are interested in science, 5.3% are interested in technology, 11.7% engineering and 2.1% mathematics (ASTRA, 2013). This study is important to determine whether this STEM program has made a statistically significant difference in STEM education by growing a pipeline from K-12 schools to college.

### Limitations

The STEM program is part of an elementary to middle to high school feeder pattern with similar goals for the program, expectations for students, professional development for teachers, and resources including technology and curriculum. The

use of a single school district may yield homogeneous career aspirations of students in the same geographic region due to their similar experiences and culture. Fields of study in college may be limited by the socio-economic status, parent education level, types of jobs available in the area, and lack of a four-year post-secondary institution in the geographic region. The study does not include other factors such as self-efficacy of math and science skills, or parental influences on student career choices. This STEM program also includes other goals, like increasing science and math achievement as measured by Advanced Placement and SAT scores, which will not be evaluated in this study.

Another limitation of the study is lack of information on whether students ultimately obtain a STEM career. It is not a longitudinal study so if students who graduated from high school interested in a STEM field successfully earn a college degree in a STEM field or obtain a job in a STEM field is unknown. The students in the school district's first graduating STEM class are just finishing college if they obtained a four-year degree. Additional research in a few more years could determine whether the STEM program promoted students through the pipeline to be hired for STEM jobs but this is not the purpose of the current study.

### Definition of Terms

*STEM careers.* Jobs related to or requiring the study of the STEM fields of science, technology, engineering, or mathematics. STEM careers require preparation through post-secondary education ranging from technical schools to doctoral studies. Examples of STEM careers include, but are not limited to scientists, technicians, engineers, and mathematicians.

*Non-STEM careers.* Jobs not related to or not requiring the study of any of the STEM fields. All careers other than STEM careers are considered non-STEM careers. It should be noted that jobs related to the fields of education and healthcare are non-STEM careers for the purpose of this study.

*STEM pipeline.* The pathway of students from K-12 schools to college and then to fill jobs in STEM careers. The STEM pipeline includes students who are prepared for STEM careers with the necessary science, technology, and mathematics skills. The purpose of the STEM pipeline is to motivate more students to continue this pathway by inspiring them in STEM careers at an early age.

*STEM program.* A cohort of less than 30 students per grade who apply and are selected to participate in the school district's STEM program from grade 3 through grade 12 each year. Students engage in STEM-embedded lessons in rigorous science, mathematics, and technology courses. At the high school level, students participate in engineering courses including principles of engineering, engineering design and development, computer integrated simulation, aerospace engineering, digital electronics, and a capstone project or internship.

*Non-STEM program.* The regular program of study provided to all students. Students not in the STEM program are in the non-STEM program. The non-STEM program does not include any STEM courses other than regular science classes, mathematics classes, and the graduation requirement of Foundations of Technology.

*STEM students.* Students who graduated from the STEM program by participating in the STEM program from grade 3 through grade 12 and meeting all of the program requirements including STEM course participation and performance.

STEM students may have chosen to pursue STEM careers or non-STEM careers after high school graduation.

*Non-STEM students.* Students who graduated from the comprehensive high school where the STEM program is located, but are not in the STEM program. Non-STEM students did not participate in the STEM program and did not participate in any STEM courses. Non-STEM students may have chosen to pursue STEM careers or non-STEM careers after high school graduation.

## Chapter 2: Literature Review

### Organization of the Review

Better preparing high school students for college, particularly science, technology, engineering and mathematics (STEM) careers, is a major focus of national interest and education reform. This chapter will begin with the definition of STEM and an overview of the importance of STEM in regards to inter-national competitiveness and job availability. The history of STEM education will include federal initiatives and state programs to increase the STEM pipeline. Research will be presented about three major areas associated with this study: STEM career predictors, women in STEM, and K-12 STEM programs. The research on STEM career predictors includes studies on academic achievement associated with STEM aspirations, particularly mathematics. Other STEM career predictors supported by research included a student's intrinsic motivation and family influence on their career choice. The research on women in STEM includes gender equity studies and strategies to interest and retain women in STEM fields. Studies on K-12 STEM programs and high school STEM programs primarily consist of program evaluations and effectiveness. The chapter concludes with gaps in the research and the need for the present study, national call for more STEM research, and the priorities of the local school district.

### What is STEM?

The acronym STEM is fairly specific with one word representing each letter; however, there is no standard definition for what constitutes a STEM career or STEM

job. Scientists, technicians, engineers, and mathematicians consistently make the lists of STEM occupations, but there is less agreement about whether to include other positions such as educators, managers, healthcare professionals, and social scientists. The Economics and Statistics Administration (ESA), which is part of the U.S. Department of Commerce, defines STEM jobs as “professional and technical support occupations in the fields of computer science and mathematics, engineering, and life and physical sciences” (Beede et al., 2011, p. 2). ESA excludes education, business, healthcare, and social sciences.

The U.S. Congress Joint Economic Committee (JEC) shares a similar definition of STEM occupations as the ESA, except the JEC does not include technical support. The JEC definition of STEM is “life sciences except medical sciences, physical sciences, mathematics and statistics, computing, and engineering” (U.S. Congress Joint Economic Committee Chairman’s Staff, 2012, p. 1). The JEC report even mentions the disagreement with regard to precisely which degrees and occupations are STEM and advise the reader that their definition does not include manufacturing and processing, and architecture and building.

The American Association of University Women (AAUW) defines the term STEM as “the physical, biological, and agricultural sciences; computer and information sciences; computer and information sciences; engineering and engineering technologies; and mathematics” (Hill, Corbett & Rose, 2010, p. 2). The AAUM further clarifies that social and behavioral sciences, such as psychology and economics, are not included, nor are health workers, such as doctors and nurses. The AAUW definition of STEM would be the same as the ESA definition, except in the

area of education. ESA does not include the field of education as STEM, however, AAUW includes college and university STEM faculty but high school teachers in STEM subjects are not included as STEM. Within the AAUM report, data from the National Science Foundation is cited as including social scientists but not medical professionals (Hill et al, 2010). The National Science Foundation definition of STEM careers differs from the ESA definition which does not include any social scientists.

For the purposes of this study, the researcher had to determine a common definition of STEM careers despite the lack of consensus in the STEM professional community. Based upon the definitions reviewed, the researcher decided to utilize the ESA definition. The ESA definition closely aligns with the engineering emphasis of the STEM program being evaluated. The STEM program in this study also does not focus on healthcare or medical careers, but there are other programs in this school district for those fields. The ESA also provides lists of STEM occupations and STEM college majors which were utilized by the researcher when coding STEM careers. This study utilizes one of the original, most common and restrictive definitions of STEM careers.

### *Importance of STEM*

The National Science Board recognizes the need for STEM innovators to develop new products, services, and processes essential to the role of the United States as a global leader. “To ensure the long-term prosperity of our Nation, we must renew our collective commitment to excellence in education and development of scientific talent. Far too many of America’s best and brightest young men and women go unrecognized and underdeveloped” (National Science Board, 2010, p. 1).



The United States continues to fall behind key international competitors across a wide set of different measures of STEM preparedness. Canada, Mexico, and Germany graduate more STEM students as a percentage of all degrees than the United States does (U.S. Congress, 2012). The report *Rising Above the Gathering Storm* proclaimed, “In South Korea, 38% of all undergraduates receive their degrees in natural sciences or engineering. In France, the figure is 47%, in China 50%, and in Singapore 67%.; but in the United States, the corresponding figure is only 15%” (Committees, 2007, p. 16).

Over the past 10 years, growth in STEM jobs was three times as fast as growth in non-STEM jobs. “There was a 7.9% growth from 2000 to 2010 for STEM employment compared to 2.6% employment growth for non-STEM jobs” (Langdon, McKittrick, Beede, Khan & Doms, 2011, p. 2). STEM workers are also less likely to experience joblessness than their non-STEM counterparts. Even at the height of the recession, a survey of manufacturers found that over one-third were experiencing shortages of engineers and scientists (U.S. Congress, 2012). STEM workers command higher wages, earning 26% more than their non-STEM counterparts (Langdon et al, 2011). “Those with graduate degrees in a STEM job earned more than \$40 per hour, nearly \$4.50 more per hour on average than those with non-STEM jobs” (Langdon et al., 2011, p. 2).

United States businesses frequently voice concerns over the supply and availability of STEM workers. In 2002 there were four million ninth graders in the United States. By 2011, only 4% of this group graduated from colleges with degrees in the STEM areas (National Center for Education Statistics, 2012). The most recent

ten-year employment projections by the U.S. Labor Department show that of the 20 fastest growing occupations, 15 of them require significant mathematics or science preparation to successfully compete for the job.

STEM skills are in demand in Maryland and STEM skills have stayed in demand even through the economic downturn. Business leaders in Maryland have sounded an alarm, because they cannot find the STEM talent they need to stay competitive (Change the Equation, 2013). There are more than three STEM jobs available for every unemployed person and two unemployed people for every non-STEM job available in Maryland. An estimated 241,000 STEM-related jobs need to be filled in Maryland by 2018 at an average annual salary of \$74,958 or higher (STEMconnector, 2011). The STEM-related jobs will be in the areas of computer and mathematics science, and engineers and technicians, with almost all requiring a college degree.

Despite the evidence, there is criticism against the importance of STEM. There are critics who argue that STEM is not the answer to our national struggle and has been over-emphasized. Columnist Fareed Zakaria argues that broad-based learning and a well-rounded liberal education are what our nation's children need to succeed in a society that emphasizes learning, thinking, and writing (Zakaria, 2015). The interpretation and comparison of inter-national test scores do not show the whole picture of American education. Zakaria insists that companies prefer strong basic skills to narrow expertise and workers need critical thinking, creativity, and social skills. Critics of STEM encourage students to follow their passion and study society because "America's obsession with STEM education is dangerous" (Zakaria, 2015, p.

1). Perhaps the critics against and advocates for STEM can come together with programs that ignite the passion of students for STEM and inspire them to study how STEM careers can improve society.

### *STEM Education Initiatives*

At both the national and state level there is a focus on the need for STEM education and a need to encourage students to enter STEM fields. “Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been” said President Barack Obama in his address to the National Academy of Science (Governor’s STEM Task Force, 2009, p. 2). In a global economy, America’s competitive edge depends in large measure on how well our schools prepare tomorrow’s workforce. In November 2009, President Obama launched his “Educate to Innovate” campaign for excellence in STEM education with \$260 million in public-private investments. “Reaffirming and strengthening America’s role as the world’s engine of scientific discovery and technological innovation is essential to meeting the challenges of the century,” said President Obama, “I am committed to making the improvement of STEM education a national priority” (Office of the Press Secretary, 2009, p. 1).

President Obama has identified three overarching priorities for STEM education: increasing STEM literacy for all; improving science and math teaching; and expanding education and opportunities for under-represented groups. The STEM Education Innovation Act of 2011 was passed “to stimulate collaboration with respect to, and provide for coordination and coherence of, the Nation’s science, technology, engineering, and mathematics education initiatives” (STEM Education Innovation

Act, 2011, p.1). The Bill established the position of Assistant Secretary of STEM to conduct an independent evaluation of STEM education programs. The STEM Education Opportunity Act of 2012 was passed to allow a tax deduction for higher education expenses in a STEM program of study to assist teachers (STEM Education Opportunity Act, 2012). “Federal agencies are making some 252 distinct investments in STEM education for a total budgetary commitment of \$3.4 billion” (National Science and Technology Council, 2011, p. xii).

A problem in Maryland is that although the state now has enviable prosperity and a strong knowledge-based economy, competing states significantly out produce Maryland in terms of STEM graduates, STEM workforce development, and STEM-based economic development. So for Maryland, standing still is falling behind. “Preparing our children for a knowledge-based economy is among our highest priorities as we seek to improve STEM training through the state,” said Governor Martin O’Malley (Governor’s STEM Task Force, 2009, p. 1).

Maryland has the nation’s fifth highest average income, a vibrant research and development environment, is home to an enormous research enterprise, has high quality and high volume federal research laboratories, and is home to several major research universities (Governor’s STEM Task Force, 2009). Maryland ranks number one nationwide in research and development per capita and third behind only California and Massachusetts in the total volume of research (Governor’s STEM Task Force, 2009). Maryland ranks second in the nation in professional and technical workers as a percentage of the workforce (Governor’s STEM Task Force, 2009). STEM-related industries in Maryland account for millions of dollars in economic

investments. But Maryland already suffers from a shortage of highly qualified STEM workforce. “We have approximately 6,000 STEM openings a year but only produce approximately 4,000 STEM graduates in Maryland” (Governor’s STEM Task Force, 2009, p. 3).

Fortunately, there is considerable interest among Maryland policymakers for building strong capacity in STEM areas, including education and research. As part of the national reform effort, Governor O’Malley initiated the P-20 Leadership Council of Maryland in October 2007 and created a STEM Task Force in September 2008. To succeed, Maryland must increase the number of interested, qualified, and motivated students prepared to take advantage of its highly regarded higher education system. Maryland’s efforts to attract the best and the brightest college students into STEM fields lag behind efforts in other states. Maryland must aggressively recruit and support not only the best and brightest students, but also overlooked students with the potential for college- and career-success in STEM fields. The state must expand its efforts to reach across the entire state to seek potential STEM students, especially in traditionally underserved and under-represented communities (Governor’s STEM Task Force, 2009).

Maryland Senator Barbara A. Milkulski wrote, “Students with STEM backgrounds are in demand today, so they can fill the jobs of tomorrow. Every student deserves a chance to excel in those fields” (Clem, 2013, p. 1). The \$4.35 billion “Race to the Top” federal government school grant program assures a competitive preference to states that commit to improving STEM education. STEM is mentioned 1,274 times in Maryland’s Race to the Top application (Clem, 2013).

“Maryland’s future, and that of our nation, depends in large part on how our schools prepare our children. We are placing an unprecedented priority on the STEM disciplines to assure a brighter tomorrow for everyone” said Lillian M. Lowery, EdD., Maryland State Superintendent of Schools (Clem, 2013, p. 2).

### *STEM Career Predictors*

The importance of increasing the number of U.S. college students completing degrees in STEM has prompted calls for research to provide a better understanding of factors related to student participation in these majors. A longitudinal study of pipeline persistence examined the association of educational experiences with degrees earned in STEM fields (Maltese & Tai, 2010). The findings indicate that the majority of students who concentrate in STEM make that choice during high school and that choice is related to a growing interest in mathematics and science. “When asked in twelfth grade about their plans for a college major, those who indicated a STEM field were more than three times as likely to earn a STEM degree as those who were planning for a different major” (Maltese & Tai, 2010, p. 899). The significance of this research indicates that when students have an interest in STEM when leaving high school it is a strong predictor of their eventual degree field.

A study from the University of Minnesota examined the relationship between student characteristics, high school preparation, and completion of a STEM major in college. Of particular interest to the researchers was the influence of a student’s high school mathematics curricula on STEM predictability. The study found that a mathematics curriculum, the number of math course options, and the location of the high school had no relationship on the later completion of a STEM major in college

(LeBeau et al., 2012). Students' mathematics proficiency, as measured by ACT mathematics score and high school mathematics grade point average, were found to be much better predictors of completing a STEM major in college (LeBeau et al., 2012). The results concluded that high schools who offer a variety of mathematics curricula, or just one choice, equally prepared students with the STEM skills needed to complete a college major in mathematics or engineering. The researchers recommended that those students with high achievement in mathematics need to be the focus of STEM recruitment efforts by colleges (LeBeau et al., 2012).

Participation in and performance on Advanced Placement (AP) exams was also found to predict college majors, in research by Mattern, Shaw, and Ewing (2011). This study was based on 39 four-year colleges and universities for 39,440 students in the entering class of fall 2006. Students who took an AP Exam in a particular content area were more likely to major in a related discipline and those with higher scores had an increased likelihood of majoring in that content area (Mattern et al., 2011). The relationship between AP participation and college major was stronger for STEM subject areas than others subject areas. In particular, students who took an AP Computer Science exam as well as students who took a math and/or physical science exam were much more likely to major in a STEM-related field (Mattern et al., 2011).

A recent study tested whether individuals with high math and high verbal ability in twelfth grade were more or less likely to choose STEM occupations than those with high math and moderate verbal ability. Results revealed that “mathematically capable individuals who also had high verbal skills were less likely

to pursue STEM careers than were individuals who had high math skills but moderate verbal skills” (Wang, Eccles, & Kenny, 2013, pp. 4-5). One notable finding was that the group with high math and high verbal ability included more females than males.

Our study provides evidence that it is not lack of ability that causes females to pursue non-STEM careers, but rather the greater likelihood that females with high math ability also have high verbal ability and thus can consider a wider range of occupations than their male peers with high math ability, who are more likely to have moderate verbal ability. (Wang et al., 2013, p. 5)

The pattern of gender differences in math and verbal ability may result in female students having a wider choice of careers, in both STEM and non-STEM fields, compared with males. It is also important to acknowledge the potential frame of reference effects that may lead students with high math and moderate verbal ability to feel more confident in their math ability than in their verbal ability.

A five-year longitudinal survey explored science aspirations and engagement among 10 to 14 year olds in the United Kingdom with over 9,000 students and their parents (Archer et al., 2012). Families with the strongest science interests and orientations were most likely to be middle class and White or South Asian. Their analyses highlighted the importance of social class in facilitating or constraining children’s potential science aspirations and identification. Archer et al. (2012) found that where a middle-class family and their child’s identification with science were in alignment in favor of science, the result was particularly powerful. “Hence, we suggest that even at the age of 10, many working-class children are already



disadvantaged and at risk of falling out of the leaky pipeline that leads to a science career, even if they enjoy science” (Archer et al., 2012, p. 904).

A qualitative investigation of factors promoting the retention and persistence of students of color in STEM interviewed Black and Asian college students (Palmer, Maramba, & Dancy II, 2011). Three main themes were found as factors for continuing to pursue STEM: “peer group support, involvement in STEM-related activities, and strong high school preparation” (Palmer et al., 2011, p. 495). The theme of involvement in STEM-related activities relates to this study. The STEM program provides students with a variety of STEM experiences which students not in the STEM program do not have the opportunity to experience. For example, students in the STEM program go on college fieldtrips and visit STEM businesses. Guest speakers frequently visit STEM classrooms to talk about their careers. STEM students also participate in activities including a science fair and robotics competition.

Researchers from the University of Pittsburgh studied a method for identifying variables for predicting STEM enrollment (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007). The variables found to be most valuable in identifying STEM students included measures of academic ability and self-efficacy. Quantitative measure of academic ability such as SAT mathematics score, high school grade point average, and to a lesser extend SAT verbal score are all indicators. “Self-efficacy measuring the student’s own perception of mathematical ability, confidence of their computer skills, and overall self-rating of the student’s academic ability are also good indicators of STEM interest” (Nicholls et al., 2007, p. 33).

A similar research group followed up in 2010 with a study to predict STEM degree outcomes based on eighth grade data and standard test scores (Nicholls, Wolfe, Besterfield-Sacre, & Shuman, 2010). The research was designed to help early identification of students who were potential candidates for achieving a degree in a STEM major to enable educators to offer programs designed to better enhance student interests and capabilities in those areas. The study used an integrated model and multiple statistical techniques to analyze variables available as of the eighth grade to predict STEM degree obtainment. “The most valuable predictors for determining potential for STEM vs. Non-STEM are variables measuring mathematics, science, and reading ability; variables that indicate academic commitment; and variables that measure family support for academic achievement” (Nicholls et al., 2010, p. 221).

In summary, research supports that students interested in STEM careers make that decision before graduating high school and that academic achievement, particularly in mathematics, is a strong predictor of students aspiring to STEM careers. Maltese and Tai (2010) found that students interested in a STEM career in high school are three times more likely to earn a STEM degree than those who are interested in a different college major. Strong mathematics skills were found to be predictors of STEM careers in the research by LeBeau et al. (2012), Maltese and Tai (2010), Nicholls et al. (2007), Nicholls et al. (2010), and Wang et al. (2013). The research by Nicholls et al. found eighth grade data and standard test scores in mathematics predicted STEM enrollment (2007) and STEM degree attainment (2010). Involvement in STEM-related activities (Palmer et al., 2011) and family support (Archer et al, 2012) also predicted a higher interest in STEM careers.

### Women in STEM

First Lady Michelle Obama said, “If we’re going to out-innovate and out-educate the rest of the world, we’ve got to open doors for everyone. We need all hands on deck. That means clearing hurdles for women and girls as they navigate careers in STEM” (Office of Science and Technology Policy, 2011, p. 1). The report *Women in STEM: A Gender Gap to Innovation* revealed that, although it is to their financial advantage, women present a mere 24% of the STEM workforce (Beede et al., 2011). Women hold a disproportionately low share of STEM undergraduate degrees, particularly in engineering, and women with a STEM degree are less likely to work in a STEM occupation but more likely to work in education or healthcare (Beede, et al, 2011). In June 2012, the Department of Education released a Gender Equity in Education snapshot, shedding light on the narrowing gap in girls’ participation in math and science courses as well as persisting inequalities in AP test passing. “In 2009-2010, females made up less than 25% of participants in STEM programs nationally with 21% at the secondary level and 24% at the post-secondary level” (U.S. Department of Education, 2012, p. 1).

A report funded by the American Association of University Women (AAUW) presents eight research findings that provide evidence that social and environmental factors contribute to the under-representation of women in science and engineering.

The number of women in science and engineering is growing, yet men continue to outnumber women, especially at the upper levels of these professions. In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as

boys leave high school prepared to pursue science and engineering majors in college. Yet fewer women than men pursue these majors. (Hill, Corbett, & St. Rose, 2010, p. 1)

Girls' achievements and interest in math and science are shaped by the environment around them. "One finding shows that when teachers and parents tell girls that their intelligence can expand with experience and learning, girls do better on math tests and are more likely to want to continue to study math in the future" (Hill et al., 2010, p. 30). Research profiled in the AAUW report shows that negative stereotypes about girls' abilities in math can indeed measurably lower girls' test performance. The issue of self-assessment, or how we view our own abilities, is another area where cultural factors have been found to limit girls' interest in mathematically challenging careers.

The AAUW research found that girls assess their mathematical abilities lower than do boys with similar mathematical achievements (Hill et al., 2010). At the same time, girls hold themselves to a higher standard than boys do in subjects like math, believing that they have to be exceptional to succeed in fields stereo-typed as male-dominated. Research highlighted in the AAUW report documents that the largest gender difference in cognitive ability is found in the area of spatial skills, with boys and men consistently outperforming girls and women (Hill et al., 2010). Spatial skills are considered by many people to be important for success in engineering and other scientific fields. Research finds that individuals' spatial skills consistently improve dramatically in a short time with a simple training course.

If girls grow up in an environment that enhances their success in science and math with parents and teachers encouraging girls to create a growth mindset environment, to assess their math and science skills more accurately, and to participate in spatial skills training, then they are more likely to develop their skills as well as their confidence and consider a future in a STEM field. (Hill et al., 2010, p. 90)

A longitudinal study looked at the participation in and attainment of STEM careers for males and females (Smith, 2011). The study followed students starting with their application to college through their undergraduate work and into employment at the end of the STEM pipeline. The findings suggest that almost three decades of initiatives for gender equity in math and science have had “little noticeable impact on the recruitment, participation, or persistence of females in STEM careers” (Smith, 2011, p. 993). While more women are studying science, the study found that recruitment to key areas, physics and engineering, remains stagnant.

Another study followed changes in education and career goals of 66 women who completed surveys in grade seven and then again in grade twelve identifying the desirable and undesirable aspects of mathematics- and science-based careers (VanLeuvan, 2004). Seventh grade teachers each selected girls to participate in the 1995 or 1996 career days and to become part of the study on the basis of the girls’ interest in STEM careers and above average achievement in mathematics and science. Survey results were collected again near graduation from high school. “Over time, participants’ degree aspiration and interest in STEM careers decreased” (VanLeuvan, 2004, p. 253). In grade seven, young women liked the learning and discovery and

using mathematics. But in grade twelve, some of the women disliked doing the mathematics and the hard work required. Girls' attitudes towards mathematics and sciences and their interest in related careers seem to be independent of, and do not necessarily parallel, their high school achievements in mathematics and science (VanLeuvan, 2004).

A retrospective study was conducted on how interest in STEM careers changed during high school for more than 6,000 college students (Sadler, Sonnert, Hazarr, & Tai, 2012). Overall, large gender differences in career plans were found, with males showing far more interest particularly in engineering, whereas females were more attracted to careers in health and medicine during their high school years. The key factor predicting STEM career interest at the end of high school was interest at the start of high school. "Our findings show that the high school years are characterized neither by overwhelming stability nor by total volatility of career interest, but by a complex mixture of both" (Sadler et al., 2012, p. 423). There was a lower retention of STEM career interest among females and a greater difficulty in attracting females to STEM fields during high school. Those interested in physics careers at the start of high school had the highest retention in STEM. Those with high grades in middle school mathematics courses have increased odds of being attracted to STEM at the end of high school. The research found promising chances for advancing female representation in STEM may lie in efforts to interest girls in STEM at the primary and middle school level (Sadler et al., 2012).

The last two studies by VanLeuvan (2004) and Sadler et al. (2012) particularly relate to this current study and the researcher's interest in females in a

STEM program aspiring to a STEM career. Van Leuvan (2004) found girls' interest in STEM decreased from grade seven to grade twelve yet girls continued to achieve strong skills in mathematics. Sadler et al. (2012) found gender differences on when to attract students to STEM careers with females being the most difficult to attract in high school. These two studies support the need for STEM education programs in elementary school and middle school in order to increase the number of females interested in STEM careers.

### *STEM Programs*

The 2015 federal budget includes investments in supporting more STEM-focused school districts. The budget provides \$150 million for a new program to redesign high schools to “focus on providing students with challenging, relevant learning experiences that will help them gain the knowledge and skills they will need to succeed in today’s economy, including in STEM fields” (White House Office of Science and Technology Policy, 2014, p. 1). Many school districts have used federal funds to open STEM high schools or to create STEM programs within existing schools. The two primary goals of STEM education are to improve the STEM skills of students, specifically in science and mathematics, and to increase the interest of students in continuing through the STEM pipeline to STEM occupations. There is not much research available which evaluates the effectiveness of STEM programs in meeting either goal of preparation or inspiration towards STEM careers.

A study compared the career skills and interests for students in two STEM schools to national data (Franco, Patel, & Lindsey, 2012). One school served students in grades 8-10 and planned to add grade levels each year to eventually serve

grades 6-12. Students applied for the STEM program and all students in the school were in the STEM program. The other school was a STEM-focused, early college academy that served students in grades 9-12. Students applied for the program and were admitted based on a lottery system. The second school had graduated two classes with over 50% of their graduates declaring their major field of study in STEM-related fields (Franco et al., 2012).

The KUDER Skills Assessment and Career Survey which maps student responses to 16 career clusters were administered to 422 students. The authors defined STEM-related as STEM, health services, architecture, information technology, arts audio-video technology, and communication clusters (Franco et al., 2012). For the skills inventory, the top three career cluster matches were hospitality, information technology, and education. These three career clusters were consistently the top matches in the Skills Inventory for all grade levels and both boys and girls. Three of the top six career matches in the Career Survey were STEM-related fields for both schools. “For school A, boys mapped to STEM and girls mapped to Health Science career clusters” (Franco et al., 2012, p. 20). Students in all grade levels from the two STEM schools studied had 44% and 42% anticipating STEM-related careers after graduation (Franco et al., 2012). The results provided evidence that “STEM high school students expressed career intents in predominately STEM-related careers at twice the national rate of 20% reported by the National Survey of Student Engagement” (Franco et al., 2012, p. 21). The study suggests that this STEM high school was successfully encouraging more students into the STEM pipeline in pursuit of STEM-related college studies.



However, not all studies show STEM programs are as successful. A study by Wiswall, Stiefel, Schwartz, and Boccardo (2014) investigated whether STEM high schools in New York City increase performance in science and mathematics. Initial review of the data looked as though more STEM students participate in advanced exams in the New York City Regents for science and mathematics. However, the researchers next accounted for student characteristics including past performance in middle school and socio-demographics like race or ethnicity, free lunch, English proficiency, and over-age for grade. The resulting conditions revealed that the STEM and non-STEM students had no significant difference in participation rates for advanced science and mathematics exams. “Comparison of means indicate an advantage to attending a STEM school, but more thorough analysis reduces or eliminates this advantage” (Wiswall et al., 2014, p. 100). The research found that females and males in STEM schools do better than their counterparts in non-STEM schools, but the gender gap is larger in STEM schools. “We find that STEM schools are more beneficial to males than females across several outcomes,” specifically greater participation by males in advanced science and mathematics exams reported the researchers (Wiswall et al., 2014, p. 102).

The study of STEM high schools in New York City had one finding which is very important for the study conducted by this research. The average student in a STEM school is markedly different from one in a non-STEM school (Wiswall et al., 2014). A particularly striking difference is the students’ prior academic performance in science and mathematics. “The average 8<sup>th</sup> grade math score is more than one standard deviation higher in STEMs than in Non-STEMs. This is suggestive of

substantial differences based on previous academic performance” (Wiswall et al., 2014, p. 98). These differences suggest that a comparison of the performance of STEM and non-STEM students is likely to lead to biased conclusions if the characteristics of those who attend these programs are not taken into account, particularly prior mathematics achievement. It is important for future research to consider this factor when comparing graduates who participated in a STEM program to graduates who did not participate in a STEM program.

A study of ten STEM focused high schools identified key design components (Scott, 2012). The purpose of the study was to gather data from current STEM programs so findings could be shared with school districts that are considering the development and implementation of a STEM program or school. Results found students who attend STEM-focused high schools out-performed their peers with more rigorous course requirements and electives centered on STEM. Students who attended STEM schools were engaged in real-world problem solving and completed internships and/or a capstone project. “The findings in this study are significant because they indicate that many students, when given the opportunity and support, are able to successfully complete rigorous STEM academic programs that go beyond the basic graduation requirements” (Scott, 2012, p. 30).

A study by researchers at East Carolina University tackled the question whether we are missing opportunities to encourage interest in STEM fields (Hall, Dickerson, Batts, Kauffmann, & Bosse, 2011). The purpose of the research was to better understand the important influences in career considerations crucial to help guide interventions aimed at improving career access in the STEM fields. “High

school students rated their interest as the most important consideration in a career choice with their parents' influence as second then third was the earning potential, and fourth in their ratings was the influence of a teacher" (Hall et al., 2011, p. 36). College students reported that the decision to consider a major was made in high school (Hall et al., 2011). These findings strongly suggested introduction to these fields at the secondary school level or before is paramount if students are to be encouraged to pursue STEM fields, especially engineering.

A review of STEM initiatives found numerous programs available for high school and middle school students; however, fewer opportunities exist for elementary students and their teachers. Research has shown that early exposure to STEM initiatives and activities positively impact elementary students' perceptions and dispositions (DeJarnette, 2011).

By capturing students' interest in STEM content at an earlier age, a proactive approach can ensure that students are on track through middle and high school to complete the needed coursework for adequate preparation to enter STEM degree programs at institutions of higher learning. (DeJarnette, 2011, p.77)

Elementary STEM programs studied included in-services for elementary teachers on engineering, a week long summer camp for elementary students, and after school clubs. There is a need for future elementary STEM education "to provide ample and equal opportunities for early exposure to STEM related concepts" (DeJarnette, 2011, p. 82).

A robust K-12 STEM pipeline in Kentucky was explored as an example of a successful partnership and experience (Ralston, Hieb, & Rivoli, 2013). The pipeline

includes elementary schools and middle schools feeding to a high school program utilizing pre-engineering concepts. The analysis looks at the outreach programs and curriculum at each level. The impact and sustainability of the partnership and pipeline are described. The research analyzes project outcomes as successful based upon increased enrollment and continued program growth (Ralston et al., 2013). Student outcomes are also analyzed as successful with evidence of concrete gains by students in science and engineering knowledge. The authors acknowledge the need for further research on whether more students complete a STEM field in college, specifically engineering, as a result of the K-12 programs (Ralston et al., 2013). The need for partnerships with higher education and professional organizations are strongly encouraged and would be extremely beneficial to the Kentucky pipeline recommended the researchers.

A recent study examined the impact of an afterschool program on urban high school students' skill in, and attitude about, using information technology (IT) within the context of science, technology, engineering, and mathematics lessons (Duran, Hoft, Lawson, Medjaed, & Orady, 2014). The study involved 77 participants within two cohort groups in an 18-month period. Data collected included pre- and post-surveys, IT/STEM projects, reports, and interviews. Findings indicate that the program had a significant impact on students' technology and STEM skills, use of technology, and understanding of IT/STEM careers (Duran et al., 2014). There was also evidence of some degree of impact on attitude changes toward IT/STEM and career aspirations in these fields, but further investigation was recommended (Duran

et al., 2014). More research was recommended to determine whether STEM schools or STEM programs within schools are a way to improve STEM education.

A summary of the research on STEM programs begins with the types of STEM programs studied included STEM high schools (Franco et al., 2012; Wiswall et al., 2014; Scott, 2012), after school programs (Duran et al., 2014), and an outreach program (Ralston et al., 2013). Research on STEM program effectiveness utilized a variety of data including KUDER Skills Assessment and Career Survey (Franco et al., 2012), high stakes assessments (Wiswall et al., 2014; Scott, 2012), program data (Duran et al., 2014), and student demographics (Wiswall et al., 2014 and Ralston et al., 2013). Almost all of the research found the STEM program studied to be very successful. The most important finding from the research on STEM programs which influenced this researcher's study was the recommendation by Wiswall et al. (2014) that a comparison of students in a STEM program to students not in a STEM program is going to be biased in favor of the STEM program if the mathematics achievement of the students is not similar. If the students in a STEM program have high mathematics achievement then the students in the comparison group should also have high mathematics achievement. Strong mathematics skills are a STEM predictor.

### Gaps in the Research

There are several gaps in the research on the effectiveness of STEM programs to increase the number of students interested in STEM fields after high school, especially women. Some of the gaps involve an insufficient number of studies of high school students compared to college students. There are also fewer studies of students who participate in a STEM program from elementary school through middle

school to high school. There are not many studies with a comparison between students in a STEM program and students not in a STEM program. Overall much more research is needed on the factors that contribute to choosing STEM careers to help improve STEM programming.

In regards to research populations, the study by Sadler et al. (2012) on the interest in STEM careers during high school was not actually conducted on high school students. College students reported what they remembered as their interest from the beginning of high school compared to their recent decision at graduation in studies by Sadler et al. (2012) and at East Carolina University (Hall et al., 2011). The populations for several evaluations of STEM programs were in STEM high schools where all students participated in the STEM program (Franco et al., 2012, Wiswall et al., 2014 and Scott, 2012). More research is needed on high school career interest, via intended field of study or college major, self-reported by students while in comprehensive high schools.

The longitudinal surveys by VanLeuvan (2011) were administered first in 1995 then again in 2000. Almost fifteen years have passed since this study and attitudes in regards to STEM careers may have changed. Similarly, research by Maltese and Tai (2011) on pipeline persistence utilized a data set from a study spanning from 1988 to 2001. There appears to be a gap in longitudinal research during the last decade. The AAUW report (Hill et al., 2010) compiled research from a variety of quantitative studies and surveys about factors and perceptions of women about STEM careers. However, the AAUW did not complete a comparative study on

the factors and perceptions of men about STEM careers. Some of the research on STEM equity is missing the comparative analysis between the genders.

The case study of ten STEM high schools provided a holistic description of each program including the vision, entrance requirements, academics and student population (Scott, 2012). Further study is needed to learn the long term impact and effectiveness of each STEM high school. The author concludes, “We need to track progress to determine if students who completed these programs chose to pursue STEM degrees” (Scott, 2012, p. 39). The study of two STEM high schools in New York City found that for average students many of the effects of attending a STEM high school are not significant. The study focused on the goal of preparation with STEM skills by measuring participation in science and mathematics Regents exams. However, the researchers concluded that STEM schools may have a significant effect on later outcomes. “Students who attend STEM schools may be more likely to enroll in college, take STEM subjects, major in STEM subjects and/or follow STEM careers. This important question deserves the attention of future research” (Wiswall et al., 2014, p. 104).

The study conducted by this researcher is designed to purposefully fill several of the gaps in the researcher. This study focuses on STEM career aspirations of students just before they graduate from high school. The STEM program evaluated in this study is a K-12 STEM program and is a STEM program within a comprehensive school with students who are not in the STEM program. This researcher also determined to not categorize medical fields as a STEM career.

### *Need for this Study*

There is a national call for research in a variety of reports from the National Math Panel, National Science Board, and legislation from both the President and Governor. The “Prepare and Inspire: K-12 Education in STEM for America’s Future” report to the President from PCAST in September 2010 provides a strategy for improving K-12 STEM education that responds to the tremendous challenges and historic opportunities facing the Nation.

We envision a two-pronged strategy for transforming education. We must prepare students so they have a strong foundation in STEM subjects and are able to use this knowledge in their personal and professional lives. We must inspire students so that all are motivated to study STEM subjects in school and many are excited about the prospect of having careers in STEM fields.

(President's Council of Advisors on Science and Technology, 2010, p. 1)

There is also a need for this study to add to the research on STEM programs in high schools across the country. Inventories of federal funds spent on STEM education, included program evaluations, are needed. The National Science and Technology Council (NSTC, 2011) reviewed a range of evaluation designs where the most commonly used design was a pre-post gain comparison design without matched comparison groups. “Education investments have been less thoroughly evaluated. Only 40% of these investments have been subject to any kind of outcome data collection” (NSTC, 2011, p. 38). General conclusions by the NSTC report (2011) indicated a lack of evidence for evaluation of whether students actually entered STEM careers after participating in federally funded programs.



There is a need to track students' educational progress to determine if students who completed STEM programs chose to pursue STEM degrees. "Further study is needed to learn the long term effectiveness of each of the STEM school models" (Scott, 2012, p. 38). Questions to be answered include: Are specialized STEM high-school graduates more likely to remain in the STEM pipeline than students with similar achievement and interests who attended regular public high schools? Which educational and instructional practices used by specialized STEM high schools are associated with higher STEM pipeline retention rates in college and higher rates of entrance into STEM-related professions (Scott, 2012)? Although many studies find factors, additional areas for research are apparent. All studies, whether quantitative or qualitative, should investigate successful pipeline programs in STEM that effectively transition students from secondary to postsecondary context (Palmer et al., 2011).

## Chapter 3: Methodology

### Rationale

The vision of the STEM program being evaluated, and a goal of many secondary STEM programs, is to increase student interest in pursuing STEM careers after they graduate from high school. Students participate in this school district's STEM program from grade 3 through grade 12. The program is part of a feeder pattern with one elementary school, one middle school, and one high school. This STEM program is part of comprehensive, public schools with a cohort of less than thirty students at each grade level. Approximately 200 other students in each grade level at the schools do not participate in the STEM program. A STEM program is the subject of this study; it is not an all-inclusive STEM school. The school district began the STEM program at the elementary level in 2003 with a grade 5 class and added grade levels each year. The first cohort of students who participated in the STEM program from elementary school through high school graduated in 2011. It is time to begin evaluating whether the goals of the STEM program have been achieved.

The STEM program includes courses, resources, and activities for the STEM program which are not available to students who are not in the STEM program. At the elementary and middle school levels, students participate in STEM mathematics, STEM science, and STEM technology courses with their STEM classmates. At the high school level, STEM students take Project Lead the Way (PLTW) pre-engineering courses together each semester. All of the STEM courses from elementary through high school utilize STEM skills and STEM problem solving on a

regular basis with activities that integrate at least three of the disciplines in science, technology, engineering and mathematics. Teachers of STEM courses attend training each summer and participate in professional development as a STEM team during the school year. Students in the STEM program also have more technology resources with class sets, or in some cases individual access, to tablets and laptops for research. In addition to fieldtrips, guest speakers, and STEM fairs, students complete a culminating project and internship their senior year in an engineering field.

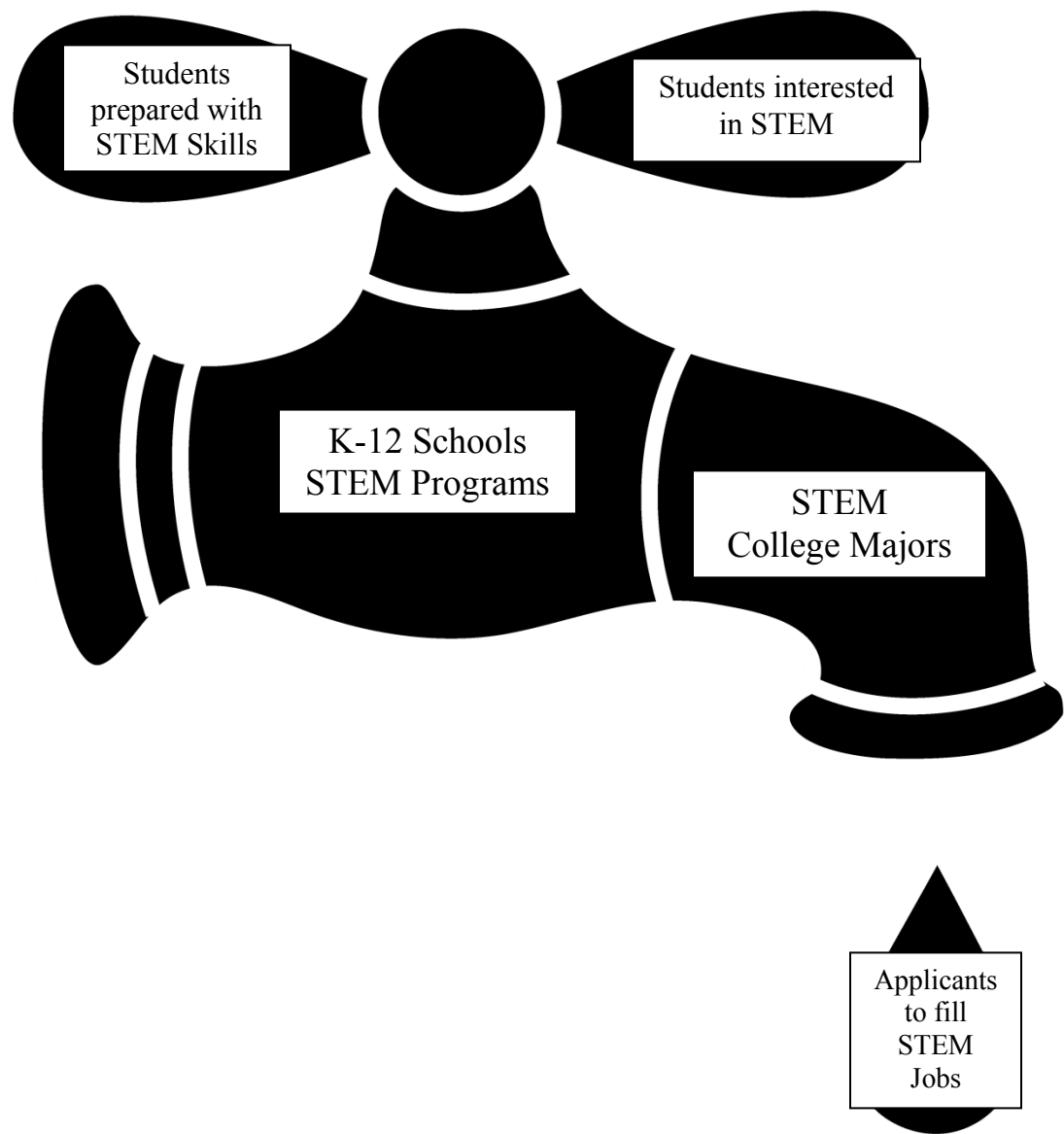
There is a sense of urgency within the school district to measure the success and effectiveness of the STEM program. The school district has been financially supporting the STEM program for over a decade as the program has grown from one grade to now include 10 grade levels. The district has provided additional staff, paid for professional development, purchased resources and upgraded technology to support the STEM program in one elementary school, one middle school, and one high school. The school district is ready to determine the return on their investment. This study evaluates the degree to which being in the STEM program makes a difference in increasing interest in pursuing a STEM-related field in college. The study also determines whether participating in the STEM program significantly increased female students' interest in aspiring to STEM careers after high school.

### *Conceptual Framework*

The conceptual framework for this study is based upon the idea of the STEM pipeline which is referred to in recent literature and research about STEM education. The pipeline refers to the path of students from K-12 schools to college to STEM occupations. Right now there is not enough “flow” of students from secondary

schools interested in STEM to fill all of the STEM jobs available at the end of the pipeline. STEM programs such as the one involved in this study are supposed to increase the number of students interested in pursuing STEM occupations and hence increase the flow of the pipeline to help fill the job demand. This study will compare the size of the “flow” to STEM occupations of students who graduate from the STEM program compared with students who are not in the STEM program. Mathematics ability is important in many STEM careers so the comparison will be between students with similar mathematics achievement in elementary school.

Given the theoretical framework and supporting literature, the proposed study’s conceptual model depicts the flow of students in the STEM program from K-12 schools to college and then to STEM occupations at the end of the pipeline. Figure 3.1 illustrates two of the factors which increase the STEM flow are students prepared with STEM skills and students interested in STEM occupations.



*Figure 3.1* Conceptual framework of STEM pipeline. This figure illustrates the flow of students through the STEM pipeline to fill STEM jobs.

The goal for the conceptual framework of the STEM pipeline is for the flow to widen so that the number of prepared and interested applicants filling STEM jobs at the end of the pipeline meets the demand. Currently, the STEM path narrows to droplets of water representing qualified and motivated applicants at the end of the pipeline as seen in Figure 3.1. It is a goal of STEM programs, like the one in this study, to not only prepare students with the STEM skills which they will need but also to motivate and maintain student interest in STEM careers through each part of the pipeline so there is a wide flow at the end to fill all of the STEM jobs available.

### Research Questions

There are two primary research questions for this study related to career aspirations of students in the STEM program. The first research question is in regards to the career interests of students in the STEM program compared to students not in the STEM program.

- Does being in a STEM program make a difference whether students with similar academic achievement aspire to STEM careers? If so, to what extent?

The question is designed to compare the two groups, students who participate in the STEM program and students who do not participate in the STEM program, to determine which group is more likely to aspire to STEM-related fields of study after high school.

The second research question determines whether there is a difference in how the STEM program influences the STEM career aspirations of male students compared to female students.

- Does being in a STEM program make a difference whether male students with similar academic achievement aspire to STEM careers? Does being in a STEM program make a difference whether female students aspire to STEM careers? If so, to what extent for each gender?

The question is designed to compare the effect of the STEM program on male students versus female students. With the need to increase the number of women in STEM fields, it is important that the STEM program inspires more female students to pursue STEM careers.

Students self-report the career field they are interested in studying after high school in a Graduation Exit Survey conducted annually by the guidance counselors with all students approximately one month prior to high school graduation. Students in the STEM program are compared with other students not in the STEM program, but who are in the same high school graduation class with similar mathematics ability as measured by the grade 5 mathematics Maryland State Assessment (MSA). The researcher assumes a null hypothesis and no statistical significance when analyzing the data to answer the research questions.

### *Design of the Study*

This study is a non-experimental, quantitative analysis of data to evaluate the effectiveness of a school district's elementary school to high school STEM program in interesting more students in pursuing STEM careers. The research quantitatively compares career interests in STEM students versus non-STEM students with the same gender and similar mathematics achievement. The study uses data which is already available through the school district including grade 5 mathematics MSA scores, self-

reported career interest, and STEM program participation for students. Data was analyzed for four years beginning with the first cohort of students who completed the school district's STEM program from elementary school through middle school and through high school. Data analysis includes using cross-tabulations and Chi-Square Tests to determine if any difference in career interest of STEM and non-STEM students, or males and females, is statistically significant.

The sample includes 80 students who graduate from the STEM program during the last four years. The comparison of non-STEM students is an equal size group of 80 students for a total of 160 students analyzed in this study. Females comprise 28.75% of the sample of students in the STEM program and 28.75% of the sample of students not in the STEM program. The second research question includes 46 female students. It is worth noting that the mobility rate of students in and out of the school is fewer than 15% (Maryland Report Card, 2014) and the mobility rate of students in and out of the STEM program is even less.

Only those students in the population who attended the school district from grade 5 through grade 12 are in the sample. If a student began the STEM program but dropped out of the STEM program before graduation, then the student was not included in either the STEM or non-STEM groups. This formed a group of students with high academic achievement who were not interested in STEM careers that were not part of the sample. Likewise, if a student did not enter the STEM program until middle school or high school then the student was also not included in the STEM or non-STEM groups. This formed a group of students with high academic achievement who were interested in STEM careers but were not part of the sample



even though they were a STEM program graduate. The study also excluded any student who had participated in a STEM class for any reason but was not a STEM program graduate. These students often chose to take a STEM course because it fit their schedule, to be in class with friends, or because of possible interest in STEM. Any student who was not a STEM program graduate but had earned one or more credits in STEM courses was not included in the STEM or non-STEM groups of the study. This strict criterion for the study population sets clear definitions for the STEM program sample and non-STEM program sample before additional data was collected. Next, students who did not have an academic achievement score or a career interest are excluded from the study.

Data collection procedures are centered on the anonymous use of student records already collected and available to the researcher in a multi-step process. First the list of STEM students who graduated each of the last four years was obtained from the high school. Next the grade 5 mathematics MSA score and gender for each STEM student was determined. Another list was then generated of students who graduated from the school the same year with the same gender and had a similar grade 5 mathematics MSA score but did not participate in the STEM program. These students will be referred to as the non-STEM students or sample of students who did not participate in the STEM program. Finally, the intended field of study in college of each student, STEM and non-STEM, as self-reported prior to high school graduation was collected from the Graduation Exit Surveys. The school changed the student names to alpha codes and the year of graduation to a single cohort number before releasing the data to the researcher.

The lists of students who graduated from the STEM program and comparison students who graduated each year were available through the school guidance office, publicly acknowledged on graduation bulletins, and documented on high school transcripts. The mathematics achievement of students was determined using grade 5 mathematics MSA scores. The school district data management system Synergy keeps students records including high-stakes test scores beginning in August 2013. Archive data from the AS400 data system used before August 2013 was obtained upon request to the school district's Office for Testing and Accountability. The mathematics MSA is administered beginning in grade 3 which is also when students enter the STEM program. However, the grade 3 mathematics MSA test began as a pilot test at approximately the same time that the STEM program began so scores for grade 3 and grade 4 from 10 years ago are not available for all students. Grade 5 mathematics MSA scores are available for all students and were utilized as the similar factor of academic achievement.

The measurement tool utilized in this survey to determine students' career interest is a form used every year by the school guidance counselors to gather information about students before graduation. One month before high school graduation, seniors complete a Graduation Exit Survey and submit it to the guidance office. The first page of the Graduation Exit Survey is available in Appendix A. Students report their plans after graduation including college acceptance, career interest, and scholarships. A question on the survey form is "What will be your major focus of study?" The question is followed by a blank line for students to write their response and can be seen in Appendix A. The questions before and after this career

interest question pertain to college. The Graduation Exit Survey forms are kept by the school guidance office. Upon receiving the list of students in the survey, the responses were easily recorded. As shown in Figure 3.2, the data was organized in an Excel spreadsheet.

Student Code	Cohort Year (1,2,3,4)	Math Score (200-600)	Gender (Male or Female)	STEM Program Graduate (Yes or No)	Intended Field of Study in College Answer	STEM Career Aspiration (Yes or No)
AA	1	500	Male	Yes	Engineering	Yes
Aa	1	500	Male	No	Mathematics	Yes
BB	1	525	Female	Yes	Biology	Yes
Bb	1	525	Female	No	Nursing	No
CC	1	530	Male	Yes	Undecided	No
Cc	1	530	Male	No	Physics	Yes
DD	1	530	Male	Yes	Engineering	Yes
Dd	1	530	Male	No	Aeronautics	Yes

*Figure 3.2* Example of data organization. This figure illustrates the data collection and coding utilized by the researcher in an Excel spreadsheet format.

#### Coding Career Aspirations

The answer to the question, “What will be your major focus of study?” on the Graduation Exit Survey was utilized to determine whether the career aspiration of each student was either a STEM career or not a STEM career. The responses to the question were recorded exactly as the student self-reported in writing on the survey form. The researcher coded student responses of “undecided” and “do not know” as

not interested in a STEM career. If a student provided two responses, then only the first response was considered for the study. Students who did not respond at all were not included in the study sample. Upon receiving the data, the researcher noticed that students self-reported their career aspirations as both intended college majors and anticipated job titles. For example, one student responded that their intended field of study was biology, another student wrote pre-med, and a different student answered doctor. The researcher needed a fair and consistent way to code this variety of responses so that the study may be replicated.

There are a variety of definitions for STEM as explained in the Chapter 2 Literature Review of this study. Based upon the definitions reviewed, the researcher decided to utilize the definition of STEM from the U.S. Department of Commerce's Economics and Statistics Administration (ESA). The researcher chose this definition for coding the career interest responses because it did not include health care or education, and the ESA also provided lists of STEM college majors and STEM job titles in addition to the definition of STEM. The STEM program being evaluated in this study emphasizes engineering. Medical sciences and education fields are not part of the STEM program focus. The ESA is also very specific with the lists provided so that if this study were duplicated then another researcher would make the same decisions coding career interests as STEM or non-STEM since students provided responses in a variety of forms. So using the ESA definition in the previous example, the student who responded that their intended field of study was biology would be coded as interested in a STEM career. But the other two students who answered pre-med and doctor would be coded as interested in non-STEM careers.

The Economics and Statistics Administration (ESA) definition of STEM jobs, list of specific STEM occupations, and set of STEM undergraduate degree fields were used to code each student response as STEM career interest or not STEM career interest (Beede et al, 2011). The list of STEM occupations can be seen in Appendix B and the set of STEM undergraduate degree fields are available in Appendix C. STEM jobs are defined by ESA as “professional and technical support occupations in the fields of computer science and mathematics, engineering, and life and physical sciences” (Beede et al, 2011, p. 2). STEM occupations are divided into four categories: computer and math, engineering and surveying, physical and life sciences, and STEM managerial occupations (Beede et al., 2011).

Education, business, healthcare, and social science majors are excluded from the ESA’s set of STEM undergraduate degree fields (Beede et al., 2011). It should be noted that for this study responses of biomedical, nursing, doctor, and teacher were not coded as STEM careers; however biology and biochemistry were coded as STEM careers. Physical and life sciences are STEM careers so responses of marine biology, wildlife conservation, veterinarian, biologist, forestry, and zoology were all coded as “Yes” student aspiring to a STEM career. Other determinations that had to be made by the researcher included coding cyber security and forensic science as STEM careers; but criminal justice and security were coded as not STEM career aspirations. The coding and categorizations were aligned with the ESA recommendations as listed in Appendix B and Appendix C as closely as possible.

### Data Analysis

Data analysis procedures began with computing descriptive statistics of the sample using the Statistical Package for Social Sciences (SPSS) software package. The research questions were answered by comparing the percentage of students who responded with an interest in STEM careers for each group; students in the STEM program, students not in the STEM program, females in the STEM program, females not in the STEM program, males in the STEM program, and males not in the STEM program. Next the researcher verified that the mean grade 5 MSA mathematics score of students in the STEM program was similar to the mean score for the students not in the STEM program. Then the researcher looked at the gender demographics of the entire sample and each cohort to determine if the number of females had increased each year, varied from year to year, or remained constant for the first four years of the STEM program.

For this study, academic achievement in mathematics, STEM program participation and gender are the independent variables; whereas career choice is the dependent variable. The Statistical Package for the Social Sciences (SPSS) software package was utilized to create a cross-tabulation of students in the STEM program and students not in the STEM program with whether they have STEM careers aspirations or do not have STEM career aspirations. The actual count and expected count of each of the four outcomes are determined then an adjusted residual is calculated to show whether the degree to which the actual study outcomes are higher or lower than expected. Cross-tabulations were also calculated for gender compared

to career aspirations for both students in the STEM program as well as students not in the STEM program.

The SPSS data analysis system was also used to conduct a Chi-Square Test to determine if the cross-tabulation tables were random. The Chi-Square value was determined for each correlation of the study's categorical data. Using Fisher's Test, the p-value of the 1-sided significance test determined whether to accept or reject the null hypothesis that the dimensions were unrelated. If  $p \leq 0.05$ , then it is statistically significant and the dimensions are related. The Chi-Square Test was calculated for the correlation between the dimensions of STEM program participation and STEM career aspiration. The Chi-Square Test was also used to determine the relationship between gender and STEM career aspiration. Both students in the STEM program and students not in the STEM program were compared in the gender calculation to determine if the STEM program also influenced this relationship.

#### IRB, Human Subjects, and Confidentiality

This study meets the standards of the Institutional Review Board (IRB) to assure the protection of the rights and welfare of human subjects. Data already held by the district and school was analyzed for this study and no additional data needed to be collected. There was no interaction with human subjects needed for the study between the researcher and STEM graduates. The IRB determined this project is exempt from IRB review by exemption category 4. Exemption 4 includes research involving the collection or study of existing data, documents, records, or specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subject cannot be identified, directly or through

identifiers linked to the subjects. The researcher then obtained the permission of the school district Superintendent to access the data and utilize it for study. Student names, year of graduation, name of the school, and name of the school district were not revealed in this study in order to maintain confidentiality. All data collected for the study was kept secure electronically by the researcher then deleted after completion of the study.

### Summary of Methodology

The purpose of this study is to compare the aspirations towards STEM careers at high school graduation of students who participated in the STEM program, particularly females, to those students with similar mathematical achievement who did not participate in the STEM program. The conceptual framework is based upon the STEM pipeline which is the continuation of the education and interest of students from K-12 schools to college to occupations in STEM-related fields. The goal of the pipeline is for as many students as possible to continue their STEM interest from beginning to end in order to meet the high demand to fill STEM jobs and increase global competitiveness of the United States in STEM. The research questions are to determine the degree to which students in the STEM program are more likely to aspire to STEM careers compared to students who did not participate in the STEM program and to look particularly at female interest in STEM careers. High stakes math test scores and graduation exit survey data will be analyzed using linear regression to determine the differential effect of being in the STEM program.



## Chapter 4: Research Findings

### Overview

One of the most important sections in the STEM pipeline is the transition of high-achieving students from accelerated science and mathematics high school courses to entering STEM-related fields in post-secondary education. The President's Council of Advisors of Science and Technology (2010) recommends focusing on both preparation and inspiration to motivate students to pursue STEM careers. The purpose of this study is to determine the effectiveness of a STEM program in increasing student interest in pursuing STEM careers in college. The STEM program studied is a program within comprehensive public schools at the elementary, middle, and high school levels. Students apply to attend these schools and participate in the STEM program from grade 3 through grade 12.

The primary purpose of this study is to determine whether this school district's STEM program increases student interest in pursuing STEM careers after high school. The study analyzes the career aspirations of students in the STEM program compared to students with similar mathematics ability who did not participate in the STEM program. The first research question for this study is:

- Does being in a STEM program make a difference whether students with similar academic achievement aspire to STEM careers? If so, to what extent?

The second purpose of this study is to evaluate the effectiveness of this STEM program at increasing the number of females aspiring to STEM careers. The research compares the influence of the STEM program for male and female students. The second research question is:

- Does being in a STEM program make a difference whether male students with similar academic achievement aspire to STEM careers? Does being in a STEM program make a difference whether female students aspire to STEM careers? If so, to what extent for each gender?

This study will help determine whether the STEM program fosters the interest of females and helps to fill the national and state need for more women in STEM jobs.

### *Design and Procedures*

This study compares the intended field of study in college of students in the STEM program to students who were not in the STEM program. The purpose is to determine whether the STEM program met one of its goals of increasing the interest of students in STEM careers. The sample includes four years of students who have graduated from the STEM program. STEM students were compared to students who graduated from the same high school but did not participate in the STEM program. The comparison group also had the same proportion of males and females with similar academic achievement. Each STEM student was matched with another student in the same graduating class, with the same gender and with the same score on the grade 5 Maryland State Assessment (MSA) Math test. In using the grade 5 MSA Math score to match students, the researcher assumed that students had comparable ability in mathematics which is an important STEM foundational skill. The school utilizes a Graduation Exit Survey with a question about intended field of study in college. The responses to the exit survey were then coded by the researcher as either STEM careers or not STEM careers. Once coded and compiled in a spreadsheet, the data was explored.

When gathering the data, several STEM students were excluded from the sample for not meeting all of the criteria necessary for this study. Students who were not in the STEM program for the entire time from elementary school through high school were not included. For example, if a student did not begin the STEM program until grade 9 then they were not included in the sample. If a student only participated in the STEM program from grade 5 to grade 10 then they were not included in this study. There were a few students who did not have a grade 5 MSA mathematics score who were excluded from the sample. There were also a few students that either did not respond to the question about intended field of student or their Graduation Exit Survey could not be found, so they were also excluded. If a student was excluded from the STEM sample, then they also could not be included in the comparison group of non-STEM program students. The school district data system was used to verify that the students who did not graduate from the STEM program had not participated in the STEM program at any time and had not completed any STEM classes.

#### *Sample and Population Statistics*

The sample is comprised of a total of 160 students which includes 114 male students and 46 female students. Females represented 28.75% of the sample, the STEM program, and the comparison group not in the STEM program. Half of the sample, 80 students, participated in the STEM program. The population of the entire high school is 919 students with 481 male students and 438 female students (Maryland Report Card, 2014). Female students are 47.66% of the total school population, but only 28.75% of the STEM sample. There are approximately 100

students participating in the STEM program at the high school. STEM students represent about 11% of the total school population. For this study, STEM students were 50% of the sample.

The data gathered for this study was from four graduation years. To help protect the identity of the students, the graduation dates were not released but rather referred to by cohort. The gender demographics of the sample are shown in Table 4.1. Cohort 1 includes 36 students and 16.67% of Cohort 1 is female students. Cohort 2 is 42 total students and includes 38.10% female students. Cohort 3 is 26 students including 30.77% female students. Cohort 4 includes 56 students and 28.57% of Cohort 4 is female students. Cohort 4 included the most students and Cohort 3 included the least number of students. Both Cohorts 2 and 4 included the greatest number of females with 16 female students each. Cohort 1 had the least with only six females. As summarized in Table 4.1, each cohort is approximately the same size and females represent approximately the same proportion for each cohort. For this study, data are analyzed for the total sample and not broken down by cohort. It is interesting to notice that the cohorts are similar in size and the ratio of males to females is proportional throughout the sample.

Table 4.1

*Gender Demographics of Sample Population*

		Number of Students	
		N	%
<b>Cohort 1</b>	Males	30	83.33
	Females	6	16.67
<b>Cohort 2</b>	Males	26	61.90
	Females	16	38.10
<b>Cohort 3</b>	Males	18	69.23
	Females	8	30.77
<b>Cohort 4</b>	Males	40	71.43
	Females	16	28.57
<b>Total</b>	Males	114	71.25
	Females	46	28.75
	Cohort 1	36	22.50
	Cohort 2	42	26.26
	Cohort 3	26	16.25
	Cohort 4	56	35.00
	Total	160	100.00

*Achievement Scores Statistics*

The Maryland State Assessment (MSA) grade 5 mathematics score was utilized as the measurement to select students with similar academic achievement in the comparison group of students not participating in the school's STEM program. In this matched sample study, students in the STEM program were compared to students not in the STEM program who graduated the same year, are the same gender, and had a similar grade 5 math MSA score. The math scores ranged from 383 to 561 on a scale of possible scores ranging from 240 to 650 (Maryland Report Card, 2014). As shown in Table 4.2, the mean score of the sample population is 460.43 with a

standard deviation of 31.94. This mean falls within the Advanced Score rating between 453 and 650 on the grade 5 mathematics MSA (Maryland Report Card, 2014).

The mean score of students in the STEM program is 460.91 with a standard deviation of 33.09. The mean score of students not in the STEM program is 459.95 with a standard deviation of 30.71. The difference in mean scores between the students in the STEM program and the comparison students not in the STEM program is less than one point and both have a mean rating of Advanced Score on the math MSA. Advanced Score is the highest rating on the MSA. Math scores of the students not in the STEM program compared to the students in the STEM program were exactly the same whenever possible, but sometimes had to be the next available student in the same cohort with the same gender. Since exact MSA scores were not always available, an analysis of grade 5 math MSA mean scores and standard deviations are shown in Table 4.2 is important to verify that this study compares students with similar academic achievement.

Table 4.2

*Achievement Scores on Grade 5 Mathematics MSA*

	<i><b>M</b></i>	<i><b>SD</b></i>
<b>STEM program</b>	460.91	33.09
<b>Non-STEM program</b>	459.95	30.71
<b>All Students</b>	460.43	31.94

Other than being utilized to select the comparison group of students not in the STEM program, the math scores were not used for any further quantitative analysis

and were not needed to answer the research questions in this study. The purpose of Table 4.2 is to confirm that the students had similar academic achievement.

### *STEM Program Statistics*

Of the 80 students in the sample who participated in the STEM program, 47 students (58.75%) were aspiring to STEM careers as depicted in Table 4.3. More males than females are aspiring to STEM careers with 35 males and 12 females. Males aspiring to STEM career represent 43.75% of the students in the STEM program and females aspiring to STEM careers are 15.00%. Of the 80 students who did not participate in the STEM program but have similar mathematics achievement as the STEM students, only 32 students (40.00%) have STEM career aspirations. As detailed in Table 4.3, there are six females (7.50%) and 26 males (32.50%) who are not in the STEM program and aspiring to STEM careers.

Table 4.3

### *STEM Career Aspirations of Males and Females*

		<b>Students Aspiring to STEM Careers</b>	
		<b>N</b>	<b>%</b>
<b>STEM Program</b>			
	Males	35	43.75
	Females	12	15.00
	Total	47	58.75
<b>Non-STEM Program</b>			
	Males	26	32.50
	Females	6	7.50
	Total	32	40.00

Comparing the data in Table 4.3, more students in the STEM program are aspiring to STEM careers. More males and more females in the STEM program are

aspiring to STEM careers compared to their counterparts not in the STEM program. Looking closely at Table 4.3, the percentage of just males in the STEM program aspiring to STEM careers (43.75%) is greater than the total percentage of students not in the STEM program aspiring to STEM careers (40%). The table also shows that twice as many females in the STEM program (12) are interested in STEM careers compared to females not in the STEM program (six) interested in STEM careers.

#### *STEM Career Statistics*

Out of the 160 students in the sample, 79 students (49.38%) were aspiring to STEM careers. The students with STEM career aspirations include 47 students in the STEM program and 32 students not in the STEM program. Males in the STEM program are 44% of the students aspiring to STEM careers and the largest group. Males not in the STEM program are 33% of the students aspiring to STEM careers. Altogether females represent only 23% of the students who have STEM career aspirations. The composition of these 79 students is depicted in Table 4.4 and explored in more detail to answer the research questions of this study.

Table 4.4

#### *Composition of Students Aspiring to STEM Careers*

		<b>Students Aspiring to STEM Careers</b>	
		<b>N</b>	<b>%</b>
<b>Males</b>	STEM Program	35	44.30
	Non-STEM Program	26	32.91
<b>Females</b>	STEM Program	12	15.19
	Non-STEM Program	6	7.59



### Gender Statistics

An important aspect of this study is the comparison of males and females because the STEM program hopes to increase the number of women aspiring to STEM careers. In this sample population, there were 46 females with 23 in the STEM program and 23 not in the STEM program. A total of 18 females, or 39.13% of all females, chose STEM careers. There were 12 females, or 52.17% of the females in the STEM program, have STEM career aspiration. Only six females, or 26.09% of females not in the STEM program, have STEM career aspirations. The number of females aspiring to STEM careers is shown in Table 4.5 with the percentage this represents out of the female population.

Comparatively, the number of males aspiring to STEM careers is greater than females. In this sample population, there were 114 males with 57 in the STEM program and 57 males not in the STEM program. A total of 61 males, or 53.51% of all males, chose STEM careers. There were 35 males, or 61.40% of the males in the STEM program, have STEM career aspirations. Fewer males, only 26 or 45.61% of males not in the STEM program, have STEM career aspirations. The number of males aspiring to STEM careers is also shown in Table 4.5 with the percentage represented out of the male population.

Table 4.5

*Demographics of Male and Female Students Aspiring to STEM Careers*

		STEM Career Aspirations	
		N	%
<b>Males</b>			
	<b>STEM Program</b>	35	61.40
	<b>Non-STEM Program</b>	26	45.61
	<b>Total</b>	61	53.51
<b>Females</b>			
	<b>STEM Program</b>	12	52.17
	<b>Non-STEM Program</b>	6	26.08
	<b>Total</b>	18	39.13

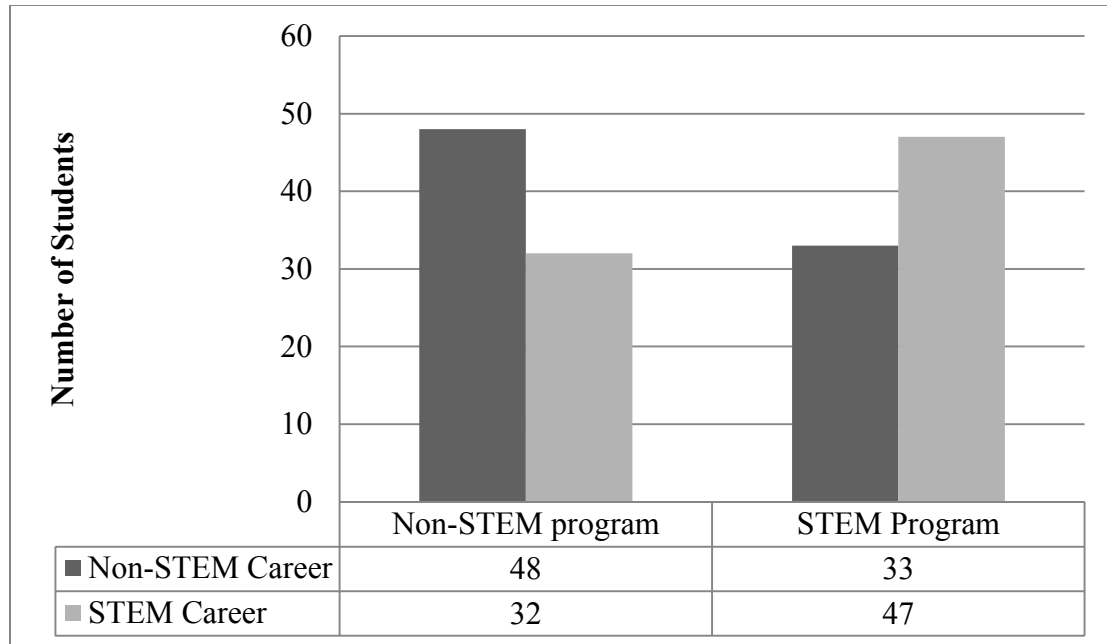
*Findings from Research Question One*

The purpose of the first research question is to determine whether more students in the STEM program aspire to STEM careers. Before reporting the findings, research question one is repeated.

- Does being in a STEM program make a difference whether students with similar academic achievement aspire to STEM careers? If so, to what extent?

A total of 79 students out of 160 total students indicated aspirations towards a STEM career. The study sample is comprised 50% of students in the STEM program and 50% of students not in the STEM program but with similar academic achievement. Figure 4.1 shows there were 47 students (58.75%) in the STEM program aspiring to STEM careers. Comparatively, only 32 students (40.00%) not in the STEM program had STEM career aspirations. These findings are higher than national data by the Alliance for Science and Technology Research in America (ASTRA) that 28.5% of students are interested in STEM careers (Alliance, 2013). However, the ASTRA data

includes all students, whereas this study is only students with a high ability in mathematics. The bar graph shows that the number of students aspiring to STEM careers compared to non-STEM careers is an inverse relationship between students in the STEM program and students in the non-STEM program with more students aspiring to STEM careers in the STEM program.



*Figure 4.1* STEM and non-STEM career aspirations of students in STEM and non-STEM programs. This figure compares the number of students aspiring to STEM careers in the STEM program to students not aspiring to STEM careers and students not in the STEM program.

A cross-tabulation generated by SPSS of the categories of STEM program and STEM careers are displayed in Table 4.6. The count is the number of students not in the STEM program who are not aspiring to STEM careers (48), the number of students not in the STEM program who are aspiring to STEM careers (32), the number of students in the STEM program not aspiring to STEM careers (33), and the number of students in the STEM program aspiring to STEM careers (47). The expected count would be if the data was randomly distributed with 40 students in each category. As can be seen in Table 4.6, the number of students not in the STEM program not aspiring to STEM careers and the number of students in the STEM program aspiring to STEM careers are both greater than the expected count.

Table 4.6

*Cross-tabulation of STEM Program and STEM Career Aspirations*

			STEM Career Aspirations		
			Yes	No	Total
STEM Program	Yes	Count	47	33	80
		Expected Count	39.5	40.5	80.0
		% within STEM program	58.75%	41.25%	100.0%
		Adjusted Residual	2.4	-2.4	
	No	Count	32	48	80
		Expected Count	39.5	40.5	80.0
		% within STEM program	40.0%	60.0%	100.0%
		Adjusted Residual	-2.4	2.4	

To determine if the data results comparing participation in the STEM program to STEM career aspiration are statistically significant, Chi-Square Tests were conducted. The Chi-Square Test is utilized to determine if the data are random. The results of the Chi-Square Tests are displayed in Table 4.7. The Pearson Chi-Square

value is 5.63. In the Fisher's Exact Test, the p-value of 0.01 is less than 0.05 ( $p \leq 0.05$ ) which is statistically significant. Hence the null hypothesis that the data are random is rejected. The Chi-Square Tests demonstrate that the cross-tabulation data comparing STEM program participation and STEM career aspirations are not random. There is a positive difference between STEM career aspirations of students in the STEM program compared to students not in the STEM program. Therefore, the researcher concluded that students in the STEM program, regardless of gender, were more likely to aspire to STEM careers than students in the non-STEM program.

Table 4.7

*Chi-Square Test of STEM Program and STEM Career Aspirations*

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
<b>Pearson Chi-Square</b>	5.63	1	.02		
<b>Fisher's Exact Test</b>				.03	.01
<b>N of Valid Cases</b>	160				

The answer to the first research question is that being in the STEM program does make a positive difference with STEM students more likely to aspire to STEM careers. To determine the extent of the difference, an odds ratio can be calculated. The difference between the number of students in the STEM program aspiring to STEM careers (47) and the number of students in the non-STEM program aspiring to STEM careers (32) is 15 which is then divided by the number of students in the non-STEM program aspiring to STEM careers (15/32) for an odds ratio of 0.47. It can be concluded in answer to the first research question; that based upon the findings, the

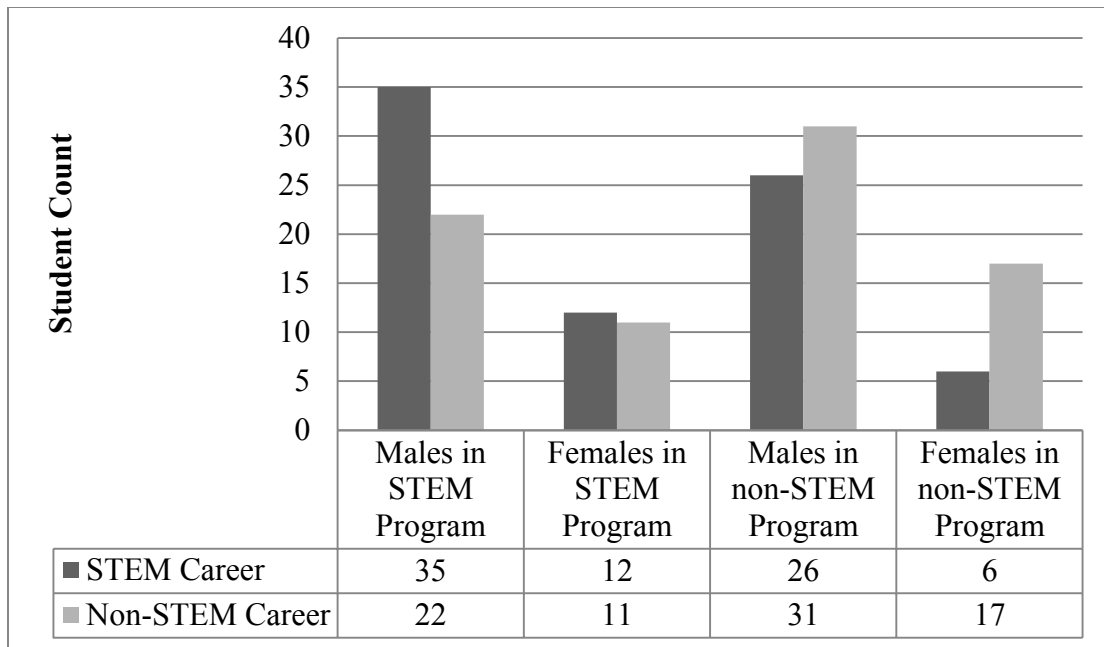
students in the STEM program are 0.47 times more likely to aspire to STEM careers compared to students with similar academic achievement who are not in the STEM program. The influence of the STEM program in 0.47 times more students with STEM career aspirations after graduation is a significant increase, and this difference is also statistically significant.

### Findings from Research Question Two

The purpose of the second research question is to determine if the influence of the STEM program based upon gender and if so, by how much. Before reporting the findings, the second research question is repeated.

- Does being in a STEM program make a difference whether male students with similar academic achievement aspire to STEM careers? Does being in a STEM program make a difference whether female students aspire to STEM careers? If so, to what extent for each gender?

Of the 79 students in the sample who are aspiring to STEM careers, 47 students are in the STEM program, and of those there are 35 males and 12 females. The 35 males aspiring to STEM careers represent 61.40% of the 57 males in the STEM program. The 12 females aspiring to STEM careers represent 52.17% of the 23 females in the STEM program. There are 26 males not in the STEM program aspiring to STEM careers which is 45.61% of the 57 males not in the STEM program. The 6 females aspiring to STEM careers represent 26.09% of the 23 females not in the STEM program. Figure 4.2 presents the career aspirations as either STEM careers or not STEM careers of the males and females in the STEM program and not in the STEM program.



*Figure 4.2* STEM and non-STEM career aspirations of males and females in STEM and non-STEM programs. This figure compares the career aspirations based upon the gender of students and program participation.

A cross-tabulation of the categories of gender and STEM careers are displayed in Table 4.8 for students in the STEM program and students not in the STEM program. The top half of Table 4.8 represents the count of 31 as the number of males not in the STEM program aspiring to careers that are not STEM, the count of 26 as the number of males not in the STEM program aspiring to STEM careers, the count of 17 as females not in the STEM program aspiring to careers that are not STEM, and the count of 6 as females not in the STEM program aspiring to STEM careers. For the bottom half of Table 4.8, the count is the number of males in the STEM program who are not aspiring to STEM careers (22), the number of males in the STEM program who are aspiring to STEM careers (35), the number of females in the STEM program not aspiring to STEM careers (11), and the number of females in

the STEM program aspiring to STEM careers (12). As can be seen in Table 4.8, the expected count is similar to the actual count for both male and female students.

Table 4.8

*Cross-tabulation of Gender and STEM Career Aspirations*

		<b>STEM Careers</b>		
		<b>Yes</b>	<b>No</b>	<b>Total</b>
<b>STEM Program</b>				
<b>Males</b>	Count	35	22	57
	Expected Count	33.5	23.5	57.0
	% within Gender	61.4%	38.6%	100.0%
	Adjusted Residual	0.8	-0.8	
<b>Females</b>	Count	12	11	23
	Expected Count	13.5	9.5	23.0
	% within Gender	52.2%	47.8%	100.0%
	Adjusted Residual	-0.8	0.8	
<b>Non-STEM Program</b>				
<b>Males</b>	Count	26	31	57
	Expected Count	22.8	34.2	57.0
	% within Gender	45.6%	54.4%	100.0%
	Adjusted Residual	1.6	-1.6	
<b>Females</b>	Count	6	17	23
	Expected Count	9.2	13.8	23.0
	% within Gender	26.1%	73.9%	100.0%
	Adjusted Residual	-1.6	1.6	

To determine if the data results comparing gender to STEM career aspiration are statistically significant, Chi-Square Tests were conducted. The Chi-Square Test is utilized to determine if the data collected are random. The results of the Chi-Square Tests are displayed in Table 4.9. The Pearson Chi-Square value for students in the STEM program is 0.58. From the Fisher's Exact Test, the p-value of 0.30 is greater than 0.05, so  $p \neq 0.05$  and not statistically significant. The Pearson Chi-Square value for students not in the STEM program is 2.60. From the Fisher's Exact Test,



the p-value of 0.09 is slightly greater than 0.05 ( $p \neq 0.05$ ) which is not statistically significant. Hence the null hypothesis, that the dimensions are not related, is accepted. Table 4.9 shows that the data differences between career aspirations of males and females are not statistically significant.

Table 4.9

*Chi-Square Tests of Gender and STEM Career Aspirations*

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
<b>STEM Program</b>					
Pearson Chi-Square	.58	1	.45		
Fisher's Exact Test				.46	.30
N of Valid Cases	80				
<b>Non-STEM Program</b>					
Pearson Chi-Square	2.60	1	.11		
Fisher's Exact Test				.13	.09
N of Valid Cases	80				

The answer to the second research question is that being in the STEM program does make a positive difference for males and females with both genders being more likely to aspire to STEM careers. To determine the extent of the difference, odds ratios were calculated for males and females. The difference between the number of males in the STEM program aspiring to STEM careers (35) and the number of males in the non-STEM program aspiring to STEM careers (26) is 9 which is then divided by the number of males in the non-STEM program aspiring to STEM careers (9/26) for an odds ratio of 0.35. This means that male students in the STEM program are 0.35 times more likely to aspire to STEM careers compared to males with similar academic achievement who are in the non-STEM program. The

difference between the number of females in the STEM program aspiring to STEM careers (12) and the number of females in the non-STEM program aspiring to STEM careers (6) is 6 which is then divided by the number of females in the non-STEM program aspiring to STEM careers (6/6) for an odds ratio of 1.0. This means that females in the STEM program are 1.0 times more likely, or twice as likely, to aspire to STEM careers compared to females with similar academic achievement that are in the non-STEM program.

It can be concluded in answer to the second research question; that based upon the findings, the male students in the STEM program are 0.35 times more likely and the female students in the STEM program are 1.0 times more likely to aspire to STEM careers compared to same gender students with similar academic achievement who are not in the STEM program. The influence of the STEM program to double the interest of female students in pursuing STEM careers after graduation is significant, especially with the national and state need for more women in STEM jobs. The effect of the STEM program based upon gender is not quite statistically significant probably due to the small number of females in the sample. The influence of the STEM program with 0.35 times more male students and twice as many female students with STEM career aspirations after graduation has a significant relative effect, especially for female students in the STEM program.

### Other Findings

The researcher made an interesting finding when coding the responses to the question about intended field of study in college responses on the Graduation Exit Survey as either STEM or not STEM careers. Only five females specifically chose to

aspire to careers in the field of engineering and all five females students were in the STEM program. The fields of study in college intended by these five females were mechanical engineering, architectural engineering, chemical engineering, biomedical engineering, and general engineering. There were no females who were not in the STEM program interested in a career in engineering. STEM classes provided hands-on experiences and instruction specifically about different types of engineering careers to students in the STEM program, but students not in the STEM program would not have this same exposure to engineering careers. The study findings conclude that the STEM program successfully inspired more female students towards engineering careers who may not have aspired to careers in the field of engineering if they had not been in the STEM program.

#### *Summary of Findings*

The data collected found more of the students in the STEM program are aspiring to STEM careers compared to students not in the STEM program with similar academic achievement. In response to the first research question, being in the STEM program made a statistically significant difference in positively influencing more students to aspire to STEM careers. For the second research question, the study found that the STEM program made a difference for both genders, but especially for females, even though the data was not statistically significant there was a relative effect.

## Chapter 5: Discussion, Conclusions and Recommendations

### Discussion about the Study

The purpose of this study was to determine whether students in a STEM program were more likely to aspire to STEM careers. The president of Project Lead the Way, a leading provider of STEM programs in K-12 education, writes that “the way we teach STEM education has never been more urgent. We need to do our part by inspiring and engaging them [students] today” (Bertram, 2014, p. 69). The researcher is also interested in the influence of the STEM program on the career interests of females in particular. “The need is great. Women are about half the workforce in America but hold less than a quarter of STEM-related jobs” (Bertram, 2014, p. 39). This study was an evaluation of the effectiveness of one STEM program in increasing interest in STEM. The program is a cohort model of approximately 30 students who are selected each year to participate in STEM courses and the program is part of a comprehensive public school with approximately 200 students at each grade level.

Students who graduated from the STEM program were compared to students who were in the same graduation class with similar mathematics achievement who did not participate in the STEM program. Research by LeBeau et al. (2012), Maltese and Tai (2010), Nicholls et al. (2007), Nicholls et al. (2010), and Wang et al. (2013) found that students with stronger math skills are more likely to choose STEM careers. To negate for influences in career choice due to academic achievement, the comparison group was selected who had similar math scores on the state assessment

as their peers when they started the STEM program. The work of Wiswall et al. (2014) supports using mathematics scores when evaluating STEM programs. They also recommend using early achievement data because participation in a STEM program may increase math skills separate from influencing career choice (Wiswall et al., 2014).

Before graduating from high school, students self-reported their intended college major which was then coded as a STEM career or not a STEM career using the STEM Occupations in Appendix B and STEM College Majors list in Appendix C. For the purposes of this study, STEM did not include medical or health careers. The lists in Appendices B and C do not include medical or health fields and the focus of the STEM program being evaluated is engineering. Students who were undecided about their intended field of study were coded as not interested in a STEM career. The data represented the first four years of the STEM program with students who had participated in the STEM program from grade 3 through grade 12. A total of 160 students were in the sample with 50% in the STEM program and 28.75% females.

### *Conclusions of the Research*

The findings indicated that being in the STEM program positively increased the likelihood that a student would aspire to a STEM career. The data in this study found 58.75% of students in the STEM program aspired to STEM careers compared to only 40.00% of students not in the STEM program aspired to STEM careers and this difference was significant. The research also found that more males in the STEM program aspired to STEM careers compared to females in the STEM program. There was also a difference between how males and females in the STEM program aspired

to STEM careers compared to males and females with similar academic achievement who were not in the STEM program. With males in the STEM program 0.35 times more likely to aspire to STEM careers and females in the STEM program 1.0 times more likely to aspire to STEM careers, the STEM program made a positive relative effect for both genders, especially females. Possibly due to the small number of females in the study, statistical significance was not proven for the effect of the STEM program on each gender.

This study found that overall the STEM program effectively met one of its goals to increase interest in STEM careers. The STEM program is indeed supporting the STEM pipeline with more students interested in STEM jobs who participated in the STEM program. Students in the STEM program are 0.47 times more likely to aspire to STEM careers. Females in the STEM program are twice as likely to aspire to STEM careers compared to females not in the STEM program but the relatively small number of females in the study may have contributed to the lack of statistically significant findings. Looking at the numbers positively, females in the STEM program were as likely to aspire to STEM careers as males in the STEM program. There was a trend for the male students in the non-STEM program to aspire to STEM careers at a higher rate than female students in the non-STEM program. Analysis of the research data showed that male students in the STEM program are the largest group interested in pursuing STEM fields after high school.

#### *Implications from the Findings*

The findings imply that the STEM program is effectively increasing the number of students interested in pursuing STEM careers. The school district may

determine that the evaluation of whether the STEM program is influencing more students to continue through the STEM pipeline to STEM careers as successful. The findings also imply that the STEM program has influenced both more males and more females to aspire to STEM careers compared to their gender-like classmates not in the STEM program. In particular, twice as many females in the STEM program intended on STEM-related college majors compared to females not in the STEM program. This suggests that the STEM program may be particularly important for fostering STEM aspirations in female students.

It should be noted that the researcher made very conservative choices when coding STEM careers, and the data still reflects a positive impact of the STEM program. By not including medical or healthcare professionals as STEM careers, the researcher aligned the definition of STEM with the STEM program's focus on engineering and the U.S. Department of Commerce's Economics and Statistics Administration definition of STEM, list of STEM college majors and list of STEM occupations. Allowing pre-med, doctors, and nursing to be included as STEM careers would have increased the number of students with STEM careers and increased the impact of the STEM program even further. However, even with a very strict interpretation of STEM as science, technology, engineering, and mathematics, the STEM program still made a very positive influence on student aspirations of STEM careers.

Although fewer females report interest in STEM careers compared to males, it is less than a 10% difference. Comparatively, there is a difference of more than 20% fewer females not in the STEM program interested in STEM careers compared to the

percentage of males not in the STEM program interested in STEM careers. What this means is that even with the STEM program, fewer female students are interested in STEM compared to male students; but, the gap between them was cut in half in the STEM program. Females in the STEM program are closer to males in matching their interest in pursuing STEM careers but the gender gap was not small enough to be significant. These results are more positive than the work of Van Leuvan (2004) that female interest in STEM decreases from elementary school to high school. These results align with the study by Sadler et al (2012) supporting the difficulty of attracting and retaining female students to STEM.

A greater disparity is in the composition of the STEM program with only 28.75% females compared to 71.25% males, so males are 1.47 times more likely to be in a STEM program. The population of the school is approximately 50% females so it is implied that the STEM program should reflect this equity. Instead, the representation of females in the STEM program of 28.75% is only slightly better than the current national work force of 24% women (Beede et al., 2011 and U.S. Department of Education, 2012). The findings indicate a need to recruit more females into the STEM program in elementary school and to retain those females in the STEM program through middle school. More females in the STEM program in high school may foster a higher percentage of females aspiring to STEM careers, especially engineering.

The findings from this study have implications to support prior research on STEM education and add to the current body of knowledge. A study of two STEM schools by Franco et al. (2012) found the program successful with over 50% of their



graduates declaring their major field of study in STEM-related careers and this study finds 58.75% of the graduates in the STEM program are aspiring to STEM careers. The work by Franco included education and healthcare careers in the definition of STEM but this current study does not include those fields. It is predicted that the results would have been greater for females if education and healthcare were included as STEM careers. The findings from this study also support the research by Scott (2012), Ralston et al. (2013), and Duran et al. (2014) that STEM programs increase student interest in STEM fields including engineering.

### Limitations

As an evaluation of a single STEM program, this study may be limited by the demographics and factors specific to the program. This STEM program is unique in that students participate from grade 3 through grade 12, and the program is contained within a comprehensive public school at each level. The students shared the same teachers, resources, and curriculum which influenced their interest in STEM. The students also represent similar demographics beyond advanced achievement in mathematics such as similar race and socio-economic background. Although students apply for the STEM program and may attend on special permission from other schools within the school district, the county does not have a four-year college or many STEM businesses which may also factor into career interests.

Another consideration is that the study is a retrospective analysis of self-reported data for the first four groups of students who graduated from the STEM program. Conclusions cannot be made on whether students actually attended college and studied the intended major or whether they have obtained jobs in STEM fields. A

longitudinal study would be needed to follow students through the STEM pipeline from elementary school to job obtainment. Conclusions should also not be made that the STEM program was the reason why a student chose a STEM career. This study does not gather data about influences on career decision making, but rather considers the STEM program as a predictor of career choice.

### Recommendations

The first recommendation as a result of the study findings is to continue the STEM program with the current teachers, resources, curriculum, and activities which motivate and interest students in STEM since the program is successfully helping students to aspire to STEM careers. The study findings that students in the STEM program are more likely to aspire to STEM careers was statistically significant. The recommendation to continue the same format and expand to include more students is based upon the current success of the STEM program. The selection of students with advanced mathematics scores on the state's high stakes assessment should continue to be a factor of STEM program admission. Efforts to recruit more students from within the STEM school may also be expanded to schools across the county to help increase participation, especially by females. This STEM program currently has female principals at the schools and several female teachers of STEM programs. More female role models could be added to these at the school level. Efforts should continue to provide internships for female students with women in STEM careers.

The second recommendation is to continue to study this STEM program. This study focused on the goal of increasing student interest in STEM careers; however, the second primary goal of the STEM program is to better prepare students for STEM

careers by increasing their STEM skills. A study of science and mathematics skills based upon state high-stakes assessment data would be available to determine whether skills increased from elementary to high school. It may be valuable to compare students in the STEM program to students not in the STEM program but with initially similar STEM skills. Another area of possible study for this STEM program is students who leave by choice during the ten years. The factors in their choice to no longer participate in the STEM program may provide information which could be used to increase both retention and recruitment into the program.

The third recommendation is to make changes to the STEM program to increase the participation and interest of female students. There appears to be a need to increase the number of females participating in the STEM program. Perhaps elementary teachers can explore the selection process to ensure that females are not being turned away. Elementary educators may consider ways to recruit more females to apply at the elementary level by providing more information to parents about the need for women in STEM. The retention of females in the STEM program could also be investigated further to determine if female students are leaving the program at a certain time or for a specific reason.

The retention of females in the STEM program through high school will be particularly advantageous to increase the interest of females in fields of engineering. Prior research found females lacked spatial skills, which accounted for the difference between males and female cognitive ability and led fewer females to pursue STEM careers where spatial skills are important, like engineering (Hill et al., 2010). However, spatial skills can be learned in a relatively short amount of time and with

practice. The STEM program in this current study may increase the interest of females by increasing the opportunities to learn and practice spatial skills in middle and high school STEM courses.

A final recommendation is to continue to study STEM programs at the K-12 level in order to increase the current research available on what works in regards to STEM education. As state and federal governments continue to invest funding for STEM education, it is important to further evaluate program effectiveness in both preparing students with STEM skills and interesting students in STEM careers. This study adds to the current body of research, but further study is still needed to increase the STEM pipeline to fulfill the demand of STEM jobs. This study meets the need to research STEM career interest and K-12 STEM programs within a school using senior year or recent graduate information with a balanced comparison group and a STEM definition which does not include medical or education fields. Additional studies which fill these gaps in the current research need to continue.

A possible extension of the current study would be to determine the influence of a STEM program within a comprehensive high school. In this study, the percentage of students not in the STEM program who aspired to STEM careers was 40.00% which is higher than national averages of 28.5% (Alliance, 2013). Further research may be able to determine whether this is due to the sample only including students with strong mathematics skills and comparable to other schools without STEM programs. It may be interesting to investigate the degree to which a STEM program within a school influences the STEM aspirations of students with high achievement in mathematics who are not in the STEM program.

### Summary

The study of the effectiveness of a STEM program to increase the interest of students in STEM careers yielded successful findings. The intended college majors self-reported before high school graduation over four years of 80 STEM graduates were compared to their peers who were not in the STEM program but had similar MSA math scores in elementary school. College majors or occupations were considered STEM careers in fields of study of science, technology, engineering and mathematics, but careers in health and medical occupations were not considered STEM careers.

The findings indicate that a higher proportion of students in the STEM program were aspiring to STEM careers compared to students with similar academic achievement who are not in the STEM program. Both male and female students in the STEM program were more interested in pursuing STEM careers compared to male and female students not in the STEM program. In answer to the first research question, students in the STEM program are 0.47 times more likely to aspire to STEM careers compared to students not in the STEM program. The answer to the second research question is that male students in the STEM program are 0.35 times more likely to aspire to STEM careers and female students in the STEM program are 1.0 times more likely to aspire to STEM careers compared to same gender students not in the STEM program. The difference made by the STEM program on gender is almost statistically significant.

The findings imply that the STEM program is indeed successful but there is still a need to interest more females in STEM. Recommendations include continuing

the current STEM program but looking more closely at the recruitment and retention of female students. Further research on STEM program effectiveness and gender differences would help educators decide what works in regards to STEM education initiatives and determine the best use of funding to support STEM programs.

# Appendix A

## GRADUATION EXIT SURVEY

NAME \_\_\_\_\_ (Please Print Neatly)  
Last, First, Middle  
M/F (circle one) Date of Birth \_\_\_\_\_ Ethnicity \_\_\_\_\_

### CONGRATULATIONS TO GRADUATES!

#### Graduate Completion Information

EVERY GRADUATE IS REQUIRED TO COMPLETE THIS FORM AND  
RETURN IT TO THE COUNSELING CENTER BY [insert date].

If you fail to return this form, you will not receive your cap & gown or your  
graduation tickets!!!!.

#### COLLEGE INFORMATION:

1. Are you planning to continue your education in the Fall? \_\_\_\_ Yes \_\_\_\_ No  
(if your answer is "NO" skip to Question #3. If your answer is "yes," proceed to  
Question #2.

2. Provide the following information.

- To which colleges, trade/technical schools did you apply?

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- To which colleges, trade/technical schools were you  
accepted? \_\_\_\_\_

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- Which college, trade/technical school will you attend in the Fall? (please  
include the complete address to send your final transcript)?  
Indicate: \_\_\_\_ Full-time or \_\_\_\_ Part- time

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- What will be your major focus of study?

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- Do you need to have your final transcript sent to the NCAA Clearinghouse?  
\_\_\_\_\_ Yes \_\_\_\_\_ No

## Appendix B

### STEM Occupations

#### *Computer and math occupations*

- Computer scientists and systems analysts
- Computer programmers
- Computer software engineers
- Computer support specialists
- Database administrators
- Network and computer systems administrators
- Network systems and data communications analysts
- Mathematicians
- Operations research analysts
- Statisticians
- Miscellaneous mathematical science occupations

#### *Engineering and surveying occupations*

- Surveyors, cartographers, and photogrammetry
- Aerospace engineers
- Architectural engineers
- Biomedical engineers
- Chemical engineers
- Civil engineers
- Computer hardware engineers
- Electrical and electronic engineers
- Environmental engineers
- Industrial engineers, including health and safety
- Marine engineers and naval architects
- Materials engineers
- Mechanical engineers
- Mining and geological engineers, including mining safety engineers
- Nuclear engineers
- Petroleum engineers
- Engineers, all other
- Drafters
- Engineering technicians
- Surveying and mapping technicians
- Sales engineers

#### *Physical and life sciences occupations*

- Agricultural and food scientists
- Biological scientists
- Conservation scientists and foresters
- Medical scientists
- Astronomers and physicists
- Atmospheric and space scientists
- Chemists and materials scientists
- Environmental scientists and geoscientists
- Physical scientists, all other
- Agricultural and food science technicians
- Biological technicians
- Chemical technicians
- Geological and petroleum technicians
- Nuclear technicians
- Other life, physical, and social science technicians

#### *STEM managerial occupations*

- Computer and information systems managers
- Engineering managers
- Natural sciences managers



## Appendix C

### STEM Undergraduate Majors

#### *Computer majors*

- Computer and information systems
- Computer programming and data processing
- Computer science
- Information sciences
- Computer administration management and security
- Computer networking and telecommunications

#### *Math majors*

- Mathematics
- Applied mathematics
- Statistics and decision science
- Mathematics and computer science

#### *Engineering majors*

- General engineering
- Aerospace engineering
- Biological engineering
- Architectural engineering
- Biomedical engineering
- Chemical engineering
- Civil engineering
- Computer engineering
- Electrical engineering
- Engineering mechanics physics and science
- Environmental engineering
- Geological and geophysical engineering
- Industrial and manufacturing engineering
- Materials engineering and materials science
- Mechanical engineering
- Metallurgical engineering
- Mining and mineral engineering
- Naval architecture and marine engineering
- Nuclear engineering
- Petroleum engineering
- Miscellaneous engineering
- Engineering technologies
- Engineering and industrial management
- Electrical engineering technology
- Industrial production technologies
- Mechanical engineering related technologies
- Miscellaneous engineering technologies
- Military technologies

#### *Physical and life sciences majors*

- Animal sciences
- Food science
- Plant science and agronomy
- Soil science
- Environmental science
- Biology
- Biochemical sciences
- Botany
- Molecular biology
- Ecology
- Genetics
- Microbiology
- Pharmacology
- Physiology
- Zoology
- Miscellaneous biology
- Nutrition sciences
- Neuroscience
- Cognitive Science and biopsychology
- Physical sciences
- Astronomy and astrophysics
- Atmospheric sciences and meteorology
- Chemistry
- Geology and earth science
- Geosciences
- Oceanography
- Physics
- Nuclear, industrial radiology, and biological technologies

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